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Editorial

Economic and Technological Advances of Green Energy and Sustainable Development: The Overview

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Currently, global science is at the forefront of discussions concerning the transition to sustainable development [1], the search for incentives for Green Economy expansion, the acceleration of the energy transition associated with an increase in the share of renewable energy sources and its recovery, the development of new types of fuel, and waste recycling. Therefore, highlighting the cutting-edge achievements of scientific thought in the field of meeting the growing demand for energy while reducing industry emissions to zero, as well as in the areas of green employment development and the equal improvement in life quality throughout the Earth, is of genuine interest for the scholar community and society.

The search for new technological and economic solutions of zero emissions and sustainable energy reflects the spiral transition from the traditional technocratic approach to the setting of a global green agenda [2].

The role of publications by academic community representatives in advancing the values and ideas of sustainable development is to promote the reduction in environmental damage without a radical reduction in energy production and its fair consumption. The risks of biosphere depletion and the global decrease in labor productivity make it necessary to develop an integrated approach to the production of green energy from alternative sources, as well as to waste recycling, green investments, and analysis of their effectiveness. Therefore, today there is a demand for discussions about the prospects and successes of introducing sustainable energy technologies, as well as about the prospects for technological convergence in the basic sectors of economy, including energy production [3].

The purpose of this special issue is to promote pluralism in the discussion of the problems of the economic and technological aspects of sustainable development, for which it is necessary to unite the efforts of international researchers for the convergence of environmental, engineering, and economic thought.

In accordance with the goal set in this Special Issue of *Energies*, *Economic and Technological Advances of Green Energy and Sustainable Development*, this Review is dedicated to the analysis of the coverage of global and national processes of sustainable development and its main segment—green energy—as well as to the discussion of zero emissions and growth in waste recycling. Here, we have summarized the contents of each of these Special Issue articles, carefully peer-reviewed and selected by the Editors from a range of sustainability and green energy publications.

In accordance with the theme of the Special Issue, *Economic and Technological Advances of Green Energy and Sustainable Development*, all published articles belong to three topics: production of green energy from alternative sources; efficiency of the use of resources in the transition to sustainable development; green innovation investment in the fuel and energy sector.

The first group is the production of green energy from alternative sources.

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M. Beer, D. Kudelas, and R. Rybár [4] consider an innovative model of a thermal energy storage device (a gyroid structure filled with sodium acetate trihydrate), and analyze its heat transfer efficiency when used in internal combustion engines to reuse the thermal energy released by them and transferred to coolant. The authors propose to eliminate the main disadvantage of phase change materials (PCM) used in thermal energy storage devices—low thermal conductivity in the solid phase (during charging and discharging)—by introducing a thermally conductive matrix into the PCM volume. To create a gyroid structure, the authors propose the use of additive manufacturing using a thermoplastic polymer in the form of a heat-conducting thread available on the market, which makes the production of equipment quite simple and inexpensive. The article presents a comparison of the main indicators of charge and discharge of the thermal energy storage device. An increase in the rate of temperature growth was revealed when the volumes of sodium acetate trihydrate were charged. The results obtained in the study indicate the prospects for the production of the innovative thermal energy storage device proposed by the authors, due to a reduced charge period and an increase in the temperature of the coolant, as well as to increased heat flux during discharge.

P. Tauš, Z. Šimková, M. Cehlár, I. Krajňáková, and J. Drozda [5] ask in their article whether it is possible in the foreseeable future to ensure the processing of the stored 200 million tons of household waste produced in the EU, taking into account all available technologies and methods for extracting useful materials and energy from them. The authors presented an approach to researching the ways of reducing the solid waste production in the countries of the European Union and developing their recycling by up to 90%, based on data for 1995–2019. The authors reasonably suppose that the calorific value of municipal solid waste burned in power plants is comparable to coal and natural gas, and makes it possible to replace most of the fossil primary energy carriers with secondary ones—the waste. At the same time, for this purpose it is necessary first to solve the problem of air pollution when burning waste to obtain energy with comparable costs when burning fossil fuels. The article reasonably considers the issue of forming an infrastructure for the production of renewable energy from household waste, based on the positive experience of Germany in the simultaneous reduction in waste production and its burning for energy production. At the same time, the strategic role of energy supply through waste recovery is noted in the context of growing disturbance of the environment and fluctuations in energy markets.

The study of L. Bednárová, H. Pavolová, Z. Šimková, and T. Bakalár [6] is devoted to the research of the economic efficiency of alternative energy sources at the facilities of the tourism industry—a rain water system for non-food purposes and a solar system for heating the water, observed in specific geographical and climatic conditions (city of Košice, Slovak Republic). The study clearly showed that the rainwater collection system on individual buildings, including tourism facilities, is able to provide up to 60% of the average water consumption by visitors (an average of 110 guests per day, use for 3 months a year by 80%), taking into account the area of the roof as a water collector. The payback period was also determined as 7 years, which is currently acceptable (in case of adverse weather conditions—up to 15 years). Of interest are the authors' recommendations for reducing the payback period of the rainwater collection and heating system, including increasing the collecting area due to additional roofing, as well as priority use in the southern and southwestern parts of Slovakia, where incoming solar energy is higher. In addition, the development of the export of manufactured water collection and rainwater heating systems will help in reducing capital costs and shortening the payback period of investments.

T. Neumann considers the prospects for the use of compressed hydrogen and evaluates the current efficiency of such systems in his article [7], devoted to the problem of reducing emissions into the atmosphere from vehicles. In general, the author connects the expansion in the share of hydrogen in the European energy sector not only with its low emissions, but also with the high level of technological replacement of traditional fossil energy sources. The advantages and limitations of the use of vehicles running on compressed hydrogen

with low emissions are analyzed in the context of various technical solutions. Based on an analysis of the prospects for the development of electric transport (taking into account the current state of the use of fossil fuels and alternative energy sources), the article shows an optimistic forecast regarding the use of hydrogen in future transport solutions. The author describes the results of an experiment for producing hydrogen at a high level, which is compared with hydrogen cells produced today, whose implementation in cars is limited nowadays. The main limitation of the study is the lack of reliable representative data for comparing the electricity consumed in the production of hydrogen to electric vehicles charging, as well as the understanding that the full recovery of electricity spent on hydrogen production is impossible. The author connects the overcoming of these limitations with the development of safe hydrogen production, for example, with the help of photovoltaic panels.

S. Zhironkin, F. Abu-Abed, and E. Dotsenko in their article [8] consider a unique process of renewable energy development in the Siberian macroregion, in which significant capacities of fuel energy and the old Soviet hydropower co-exist, against the background of an extremely low density population. By comparing the achievements in the development of renewable energy in the EU countries, China, India, Russia, etc., the authors concluded that its potential is underutilized in the Russian Federation, which is manifested in the lack of renewable generating capacities. The authors analyzed the factors of renewable energy development in Siberia (energy supply for tourism and agriculture, reduction in harmful emissions from fuel energy, diversification in energy production by companies that extract and burn fossil fuels) and concluded that the development of the energy sector should be stimulated not by investing in new capacities, but by the demand for it. In addition, it was concluded that environmental incentives for renewable energy development, the most widespread being those in China, India, the European Union, and Siberia, are of secondary importance for Siberia. In this regard, the authors give recommendations for the development of renewable energy in the Siberian Federal District, such as synchronizing the tightening of environmental requirements for fuel energy and stimulating investment in renewable energy, as well as subsidizing its non-industrial consumers.

The second group of articles is devoted to the study of the efficiency of using resources in the transition to sustainable development.

The article by M. Taušová, K. Čulková, D. Kudelas, L. Gabániová, J. Koščo, and I. Mehana [9] pose the problem of increasing the efficiency of water use in the countries of the European Union and its assessment using a number of indicators, including water productivity. The authors rightly conclude that climate change in the future can radically cut the availability of water for many people, which will lead to its scarcity. The research objectives given in the article are related to the desire to improve the sustainability of the water supply and reflect its economic feasibility, social responsibility, and environmental integrity. The observed decrease in water consumption in various sectors of the economy in the EU countries correlates with the annual increase in water productivity. As a result of the study, the EU countries were ranked according to these indicators. According to this ranking and taking into account institutional determinants, recommendations on the development of policies to reduce gaps in the efficiency of water consumption sources were made. The scientific value of the research results presented in this article is confirmed by the universality of their application in assessing the efficiency of the consumption of other natural resources—fossil energy sources (reducing the carbon footprint), the earth's surface and soil, wind, and solar.

Finally, the third group of articles is devoted to green innovations investment in the fuel and energy sector.

The article by L. Domaracká, A. Seňová, and D. Kowal [10] poses the problem of assessing the effectiveness of eco-innovations in the 10 countries of the European Union (Slovakia, Czech Republic, Poland, Hungary, Austria, Germany, France, Italy, Sweden, and Finland) to identify leading countries with super-eco-innovations, as well as countries in the "middle" zone, and outsider countries. As variables for analysis, the authors

used the following: the contribution of eco-innovations to environmental protection, as well as their results, significant for the environment, economy, and society. Based on these variables, the authors proposed an eco-innovation index. Using the example of Slovakia, the long-term motivation of firms and the population to enhance eco-innovations was analyzed, in particular, increasing the separate collection of household waste, the production of eco-capsules—innovative eco-housing, the organization of eco-shops selling goods without packaging (or in recyclable eco-packaging). As the latter, the authors highlight the promising production of eco-packaging made of cotton and beeswax, with good antifungal and antibacterial properties. Of interest are projects for the production of furniture for children, which increases in size with the child. As a result, the authors concluded that eco-innovations are becoming a factor in long-term national competitiveness in the 21st century.

The article by L. Domaracká, M. Taušová, K. Čulková, P. Tauš, and P. Gomboš [11] is devoted to the most important issues in the development of modern energy—greenhouse gas emissions and the movement towards a low-carbon economy in terms of production and final energy consumption. The authors use regression and cluster analysis with data processing using the JMP 15 software as a methodological basis. The results of the study, reflected in the article, reveal the legislative measures proposed by the authors for the transition to renewable energy sources, including promoting their diversification, increasing the efficiency of renewable energy production and their share in the overall energy balance, and increasing the energy supply of individual countries. The conclusion of the authors is also noteworthy, that the increase in energy taxation can lead to an increase in the environmental efficiency of electricity production in terms of reducing greenhouse gas emissions. As a goal of future research, the authors set an assessment of the prospects for the use of geothermal energy.

An important issue of enterprises' environmental efficiency is considered in the article by M. Asif [12] from the standpoint of the economic benefits that bring green process innovation (GPI), green entrepreneurial orientation (GPO), proactive sustainable strategy (PSS). The author used a representative sample of 294 Indian agricultural firms analyzed using Lisrel 8.80. An assessment of the impact of innovations in the field of green processes in green entrepreneurship on the environmental performance of Indian agricultural firms led to the conclusion that these processes have a positive impact on the overall entrepreneurship economic efficiency. The methods used in green agribusiness include eliminating the use of harmful substances, recycling resources, and improving the energy efficiency of processes. The effect of introducing these methods includes direct cost savings, improved reputation, and compliance with environmental standards, the trend towards the tightening of which has been observed in recent years. The article fairly presents the limitations of the current stage of research of agribusiness environmental efficiency associated with the diversity of green technological innovations, the need to analyze not only environmental and economic but also management indicators, and the focus on developing countries. The overcoming of these limitations is associated by the author with the research of environmental management systems in the planning of transition to sustainable development.

The article by S. Zhironkin and E. Taran [13] considers the diffusion of the end-to-end technologies of Industry 4.0 in the sector of fossil energy production in the context of shocks and fluctuations in the mineral resource market that accompanies the energy transition. The authors identified the main domain areas of Surface Mining 4.0: neural networks and artificial intelligence, Big Data and cloud computing, Internet of Things, digital twins, blockchain, machine vision and learning (including unmanned equipment), smart sensors, drones, and 3D visualization. In the review presented by the authors, special attention is paid to the development of ESG investments and Post-Mining, the main contribution of open-pit mining to sustainable development. The authors note that such studies are of less interest for the scholar community than the digital transformation of open-pit mining. The article reveals the horizons of the deep digitalization of open-pit mining based on convergent engineering, digital, and management technologies in the future, when in the

human-centric economy of the 21st century there will be a transformation of Mining 4.0 into Mining 5.0, with new shocks. In general, the authors conclude that in the context of growing global demand for energy, it is extremely difficult to avoid its shortage with an accelerated transition to renewable energy sources, which increases the importance of modernizing traditional open-pit mining of fossil fuels to the level of Industry 4.0.

We presume that the review of the articles presented in the Special Issue of *Energies*, *Economic and Technological Advances of Green Energy and Sustainable Development*, devoted to the problems and prospects for green energy production in the transition to sustainable development, will be of interest to the academic community and a wide range of readers. In this regard, we, first of all, want to note the demand for research into the relationship between the production of renewable energy and the reduction in accumulated waste, between the development of traditional fossil and alternative energy sources, and the impact of all this on the sustainable social- and economic development of regions and entire countries. It is also necessary to note the interest of the authors of green startups and ESG investment in the energy sector, which is aimed at reducing the gap in the level of energy innovations between countries with high and low level of sustainable development.

Feeling proud of our participation in the editing and selection of articles for the Special Issue of *Energies*, *Economic and Technological Advances of Green Energy and Sustainable Development*, we would like to say thanks to the reviewers who have made a significant contribution to cutting the diamond of scientific thought in the field of green energy and sustainable development. Without a doubt, further progress in this area depends on the diffusion and popularization of innovative ideas and knowledge in the research articles.

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References

1. United Nations. Sustainable Development Goals. 17 Goals to Transform Our World. Available online: https://www.un.org/sustainabledevelopment/ (accessed on 10 May 2023).
2. Khloptsov, D.M.; Gasanov, M.A.; Potyagail, S.V. Evolution of the technological platform of structural shifts in the economy. *Econ. Innov. Manag.* **2022**, *1*, 20–32. [CrossRef]
3. Cehlar, M. The structural role of convergent technologies in the modern economy. *Econ. Innov. Manag.* **2019**, *3*, 24–31. [CrossRef]
4. Beer, M.; Kudelas, D.; Rybár, R. A Numerical Analysis of the Thermal Energy Storage Based on Porous Gyroid Structure Filled with Sodium Acetate Trihydrate. *Energies* **2023**, *16*, 309. [CrossRef]
5. Tauš, P.; Šimková, Z.; Cehlár, M.; Krajňáková, I.; Drozda, J. Fulfillment of EU Goals in the Field of Waste Management through Energy Recovery from Waste. *Energies* **2023**, *16*, 1913. [CrossRef]
6. Bednárová, L.; Pavolová, H.; Šimková, Z.; Bakalár, T. Economic Efficiency of Solar and Rainwater Systems—A Case Study. *Energies* **2023**, *16*, 504. [CrossRef]
7. Neumann, T. Efficient Use of Low-Emission Power Supply for Means of Transport. *Energies* **2023**, *16*, 3536. [CrossRef]
8. Zhironkin, S.; Abu-Abed, F.; Dotsenko, E. The Development of Renewable Energy in Mineral Resource Clusters—The Case of the Siberian Federal District. *Energies* **2023**, *16*, 3843. [CrossRef]
9. Taušová, M.; Čulková, K.; Kudelas, D.; Gabániová, Ľ.; Koščo, J.; Mehana, I. Evaluation of Water Resources through Efficiency Index and Water Productivity in EU. *Energies* **2022**, *15*, 9123. [CrossRef]
10. Domaracká, L.; Seňová, A.; Kowal, D. Evaluation of Eco-Innovation and Green Economy in EU Countries. *Energies* **2023**, *16*, 962. [CrossRef]
11. Domaracká, L.; Taušová, M.; Čulková, K.; Tauš, P.; Gomboš, P. Development of Greenhouse Gas Emission and Evaluation of Carbon Resource Use in Chosen EU Countries. *Energies* **2023**, *16*, 1254. [CrossRef]

12. Asif, M. Environmental Efficiency of Enterprises: Trends, Strategy, Innovations. *Energies* **2023**, *16*, 2683. [CrossRef]
13. Zhironkin, S.; Taran, E. Development of Surface Mining 4.0 in Terms of Technological Shock in Energy Transition: A Review. *Energies* **2023**, *16*, 3639. [CrossRef]