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Editorial

Advances in Sustainable Development: Technological and Economic Overview

Sergey Zhironkin [1,2,3]

[1] Institute of Trade and Economy, Siberian Federal University, 79 Svobodny Av., 660041 Krasnoyarsk, Russia; zhironkinsa@kuzstu.ru
[2] Open Pit Mining Department, T.F. Gorbachev Kuzbass State Technical University, 28 Vesennya St., 650000 Kemerovo, Russia
[3] School of Core Engineering Education, National Research Tomsk Polytechnic University, 30 Lenina St., 634050 Tomsk, Russia

Today, science faces the problem of rethinking the incentives for the transition to sustainable development, including the expansion of the "green" economy, renewable energy and recycling of materials, in keeping with the fact that not all the goals set by global organizations in this area [1] have been achieved. In this regard, highlighting the most advanced scientific achievements in the field of energy jump and achieving net zero emissions, the development of "green" employment and investment, along with balanced economic growth and a uniform increase in the quality of life, requires special attention.

The need to strive for zero greenhouse gas emissions and recycling has made the whole world look for new technological solutions as well as new systems of socio-economic interactions. The spiral nature of technological and socio-economic development in the context of the transition to a "green" economy and sustainable energy means a divergence from the traditional technocratic approach to the formation of a "green" global policy agenda. The strengthening of the importance of education, environmental social activity and collective co-financing of sustainable development initiatives within the framework of Penta Helix is combined with the growing attention of states to innovations in environment management, recycling economy and low-carbon energy.

Breakthrough initiatives of the "green" economy in the consumer market include the replacement of traditional vehicles with electric ones with fast-charging batteries, the transition to biodegradable packaging, the creation of "smart" factories that produce the amount of products strictly necessary for all production-consumption chains, the use of cellulose for polymers production, the creation of floating solar panels for large water bodies and vertical multi-level farms in agriculture. At the industry level, sustainable development means the intellectualization of the design, production and consumption of energy, the recycling of the bulk of materials and the integration of international efforts to reduce fossil fuel consumption and greenhouse gas emissions.

The role of scientific publications in promoting the values and ideas of sustainable development is to combine the interests of society and business, and the potential of the research sector to reduce the burden on the environment without a radical reduction of consumption and a decrease in quality of life. Structural changes in the production and consumption of energy and energy carriers, as well as various material goods, which act as environmental pollutants and generators of biosphere depletion, are possible if new technologies of the "green" economy are widely popularized. So the large-scale discussions must be launched regarding the prospects and successes of introducing advanced energy, resource-saving technologies and recycling.

In this regard, this Editorial, "Advances in Sustainable Development: Technological and Economic Overview", is dedicated to exploring global and national opportunities to accelerate the energy transition and reduce greenhouse gas emissions, increase the share of materials recirculation without compromising the life quality of the population

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and sustainable economic growth. Below is a summary of the content of each of the articles, specially selected from a large number of publications on the subject of sustainable development's technological and economic foundations.

The article by Taghizadeh-Hesary and Taghizadeh-Hesary [2] (part of the Special Issue "Economic Analysis on Energy and Environmental Issues and Policy") presents a multilateral analysis of the problem of the impact of air pollution on the economy of South-east Asian countries from the perspective of public health. The authors examined the dilemma of accelerating economic growth through government subsidies that reduce the cost of fossil fuel use, and the growth of the latent costs—the deterioration of the quality of the workforce due to the increase in serious diseases (such as lung cancer) and the growth of the future burden of social expenses. Using such analytical methods as the panel vector error correction model and panel-generalized method of moments, the authors convincingly prove the need to subsidize the transition to renewable energy sources with a simultaneous increase in health care costs. In the long term, this can ensure the maintenance of high economic growth rates and improve the health of the population. The involvement of private investors in the development of renewable energy, according to the authors, requires the accelerated development of "green" financing ("green" bonds, "green" banks, "green" funds based on local communities), supported by the necessary changes in fiscal policy and the emergence of "green" central banks for the foreseeable future.

Panoutsou and Chiaramonti [3] (in the Special Issue "The Role of Abandoned and Degraded Land in Markets and Policy for Bioeconomy") demonstrated an original approach to growing lignocellulosic crops (i.e., Miscanthus) for biofuel production in the countries of Southern Europe, where agricultural development is limited by arid climate. The article presents the results of a study based on the input–output methodology and an econometric model used for invariant analysis of value chains—the use of biofuels for the small-scale production of heat and electricity, as well as for the production of biofuels with fast pyrolysis. The results of the analysis presented in the article showed the relationship between the applied methods of farming and the profitability of the production of biofuels and energy based on Miscanthus, while the level of environmental sustainability is high for all the reference production and supply chains considered in the article. An important conclusion of the research is the provision of positive profitability in a wide range of yields. Italy and Greece were experimentally determined to be the favorable regions of Southern Europe for Miscanthus cultivation. The author's assessments and conclusions may well be used in promoting the Renewable Energy Directive II (REDII) and achieving the goals of the Common Agricultural Policy post-2020, related to adapting the EU economy to climate change, preserving the environment, expanding the turnover of low-quality marginal lands and employment development.

In the article by Fu, Supriyadi, Wang, Wang and Cirella [4] (in the Special Issue "Energy Security as a Key Driving Factor for Socioeconomic Development: From Mitigation to Solution") the relationship between the innovative capabilities of national manufacturing companies and the achievement of sustainable development goals (by example of listed companies in China) as part of the national strategy—"Made in China 2025"—are considered. The authors used the spatial autocorrelation method and a Tobit model to identify impact of the pathways of regional innovation capacity on the "green" technology efficiency in the manufacturing industry. The main results of the study presented in the article include, firstly, a direct relationship between innovation potential and balanced socioeconomic development. Secondly, a key factor in the effectiveness of "green" technologies is the cost of human capital—public and private—in comparison with the level of waste recycling achieved. The authors associate the heterogeneity in the effectiveness of "green" technologies in China's manufacturing industry with the regional differentiation of the level of human capital development. Thirdly, the key recommendations regarding the development of "green" technologies include the creation of national engineering laboratories, the consolidation of the personnel reserve of innovation and the development of research into energy saving and environmental protection using big data and cloud computing.

The problems of reducing greenhouse gases emissions in the transition to the circular economy were analyzed by Janik, Ryszko and Szafraniec [5] from the standpoint of sustainability reports from EU energy sector. In the authors' analysis of the problems of greenhouse gas emissions in the context of an increase in electricity production, it was revealed that the quality of reports on sustainable development at the strategic level (generally) is significantly higher than at the operational level—for individual indicators. At the same time, the results of the presented research demonstrate that external influence has a statistically significant impact on the majority of indicators. The authors also found that sustainability reports with the comprehensive option are significantly more developed than other reports. An important conclusion based on the results of the study is that the disclosure of a large amount of detailed data affects the clarity of sustainability reports. With respect to area of activity and non-financial reporting obligation, a statistically significant difference appeared for the occurrence of GHG issues at the strategic level. In general, most of the analyzed indicators reached higher values for companies operating internationally.

Focusing on simulation and serious games in teaching, de la Torre, Onggo, Corlu, Nogal and Juan in the article [6] (belongs to the Special Issue "Toward the Circular Economy in the Energy Sector: The Role of Higher Education") observe the issues of sustainable energy production and transition to a circular economy. The article discusses the methods of spreading the knowledge about alternative energy and the conservation of natural resources in modern society, the role of simulation and serious games in teaching related to sustainable development, which can help in the decision-making process. Particular attention is paid to the use of serious games that add high emotional involvement to learning the basics of the circular economy, which allows students to understand different points of view on sustainable energy and recycling policies. The article convincingly proves that students studying strategic and operational management, engineering and business analytics need to develop the skills to solve non-trivial cognitive problems arising from the multifaceted problem of developing sustainable energy and recycling—complex interactions of socio-economic, technical and environmental systems. The importance of using the simulation method is substantiated by the authors from the standpoint of the need for critical knowledge and skills for students to develop products and evaluate market strategies for the circular economy.

In the article by Tutak, Brodny and Bindzár [7] (part of the Special Issue "Energy Economic Analysis: Energy Transition and Sustainability"), the authors discuss the integration role of energy policy in achieving the goals of the Sustainable Development Concept—economic, environmental and social ones. Using the methodology based on the analysis of indicators characterizing the four main dimensions of energy and climate resilience (energy, climate, social sphere and economy), the authors applied the entropy-complex-proportional-assessment method to make decisions on a variety of criteria. As a result, an assessment of changes in the system of energy and climate sustainability in EU countries for 2009–2018 was presented. The authors determined the high effectiveness of the concentration of financial resources in groups of countries with similar conditions and problems of sustainable development (such as Sweden, Denmark, France and Austria), cooperation with which should accelerate the achievement of the goals of the European Green Deal Strategy and Agenda 2030 for another group of countries (such as Bulgaria, Cyprus, Poland, Estonia, Greece, Lithuania, Malta, Czech Republic and Luxembourg), taking into account their specialization.

In the article by Adisorn, Tholen and Götz [8] (part of the Special Issue "Circular Economy in Low-Carbon Transition"), the issues of widespread implementation of the Digital Product Passport as a contribution to a circular economy are considered. In the context of the almost complete absence of scientific discussion about the Digital Product Passport, the article presents the concept of its development and implementation, revealing the potential advantages of a single information point in the circular economy system, which ensures a high level of environmental safety of production and consumption. The main benefit of the Digital Product Passport is to provide information about recycling in the

production of each product with minimal transaction costs, since for high-value products with a longer service life, the volume of production information and the costs of it increase exponentially. Therefore, according to the authors, the Digital Product Passport should help investors understand the image advantages of sustainable products entering the market. Creating a certain groundwork for future research, the authors see the development of Digital Product Passport concept in the search for detailing for a wide range of groups of real products.

The following two articles as a part of the Special Issue "Behavioral Models for Energy with Applications" reveal the relationship between conventional and "green" energy consumption and economic growth.

Assessing the impact of the globalization of the innovation process in industry on CO_2 emissions (by the example of South Korea), Adebayo, Coelho, Onbasıoglu, Rjoub, Mata, Carvalho, Rita and Adeshola [9] use the autoregressive distributed lag bounds testing method to assess long-run dependences of renewable energy consumption, environmental degradation/restoration and economic growth. The published results of the study make it possible to predict CO_2 emissions based on an analysis of the links between technological upgrading, globalization, energy consumption, and economic growth. The authors determined that economic growth in South Korea has a negative impact on the environment, as it is highly dependent on the use of energy produced from non-renewable sources; the effect of globalization also leads to changes in CO_2 emissions. To reduce them, the authors propose to strengthen the incentives for investing in technological innovations that increase the efficiency of using traditional energy sources and make it possible to reduce the cost of producing sustainable "green" energy, and increase its share in the overall energy balance.

Baydoun and Aga [10], using the example of the Persian Gulf countries, consider economic growth and energy consumption as factors for reducing environmental sustainability, and globalization as a factor for increasing it. The reliability of the results of the analysis of these factors' mutual influence is ensured by the use of a wide range of statistical tools: cross-sectional dependence, slope heterogeneity, Pesaran unit root, Westerlund cointegration, cross-sectionally augmented autoregressive distributed lag, Dumitrescu and Hurlin causality. The application of these approaches resulted in the development of the authors' proposals to improve environmental sustainability for the Persian Gulf countries. They are increasing the openness of national companies to new markets and investors in technological innovations, expanding the financial base of public–private partnerships in the production of "green" and renewable energy, the conduct of energy conservation policies that strike a balance between energy consumption, environmental deterioration/improvement and economic growth. Further research in this area is seen by the authors in the context of using an asymmetric approach and additional variables in the analysis of the relationship between indicators of environmental degradation, energy consumption and economic growth.

A full-scale study by Rehman, Ma, Radulescu, Sinisi, Paunescu, Alam and Alvarado [11] (part of the Special Issue "Energy Policy for a Sustainable Economic Growth") examines the relationship between urban agglomeration and economic growth, greenhouse gas emissions and nuclear and coal energy generation (using the example of Pakistan over almost half a century—1972–2019). The results of a long-term analysis allowed the authors to establish the existence of an unfavorable relationship between economic growth and greenhouse gas emissions during the rapid growth of urban agglomeration and the development of coal energy. On the contrary, the development of nuclear energy has a positive impact on the environment in the context of accelerating economic growth. At the same time, despite the fact that Pakistan produces less greenhouse gas emissions than industrialized countries, the national energy industry needs a more coordinated development, with an increase in the share of imported clean coal, the use of biomass as an energy source. According to the authors, the solution of the energy mix dilemma for Pakistan should be facilitated by investments in "green" energy—solar, wind and hydropower generation sectors.

At the end of this review of a number of articles in *Energies*, devoted to the advances in sustainable development and generating high interest from the scientific community, we can state the following. First, the interest in the in-depth study of the relationship between technological breakthroughs in the field of "green" and recycling economy and the improvement of economic dynamics is dictated by the growing separation between the countries leading the innovation process in the environmental sphere and the countries catching up in terms of development. Secondly, although the key sustainable development goals have not yet been achieved on a global scale, cutting-edge "green" start-ups represent a significant step towards achieving them. Thirdly, we see the future of research in the field of technological and economic aspects of sustainable development in the search for means to reduce the gap between countries in the production and consumption of "green" energy and recycled materials, encouraging "green" investment and jobs.

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