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Editorial

Recent Advances in the Energy Market Development: Current Challenges and Perspectives of Energy Crises in Academia

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1. Introduction

The current challenges in the energy crisis, triggered primarily by the Russo-Ukrainian conflict, have had an unprecedented impact on investment in the energy market. The pre-war COP26 meeting in Glasgow in 2021 was a defining moment for the transition to sustainable energy and overcoming the COVID-19 pandemic. Government spending on renewable energy transitions after the COVID-19 pandemic is estimated to have stood at $1.1 trillion [1].

Efforts to strengthen energy security in order to overcome the consequences of war and crisis, and address the pandemic, to secure the energy balances of countries are based on the COP26Energy Compact signed by the global community. In the EU, a variety of policy documents and regulations have been presented as a basis for decarbonization and energy efficiency (Energy Roadmap 2050, Directive 2012/27/EU and 2014/94/EU) to promote the green transition. The EU Green Deal, the primary piece of legislation concerned and a benchmark for other countries, comprises a comprehensive set of policies aimed at achieving a zero-emission economy countries [2].

When gas prices reached incredible heights ($140 per barrel) and provoked a huge inflationary spiral and cost-of-living crisis in many countries, shattering the traditional supply chains and perspectives on climate change mitigation targets [3], it became apparent that new measures are needed to maintain energy security in these turbulent times.

Despite their diversity (US Inflation Reduction Act, the REPowerEU Plan, clean energy and renewables transition in China, Japan, Korea and India), these plans in general tend to promote investments in the region of $2 trillion by 2030 [1].

However, this is a still dubious estimate for providing sufficient resources to close the gap between the reality and objectives in terms of attaining Sustainable Development Goal 7 Clean and Affordable Energy, especially when the growth of global CO2 emissions is estimated to have stood at 6% in 2021 and will increase by 14% in the next 10 years [4–6].

A significant contribution to the solution of the current energy crisis is being made by current areas of academic research related to financing the sustainable development of the energy sector [7], renewables, energy transition [8,9], and measures to promote energy affordability, efficiency, and security The modelling and forecasting of investments in the energy sector, their risks, profitability, and role in climate change mitigation and energy consumption is another essential task being performed by researchers [10].

2. Literature Review

The academic landscape in relation to the above line of research is puzzled. It can be differentiated by type of energy sources (traditional (fossil fuels) or alternatives (renewable)), the stage of the energy cycle (production, distribution, consumption), or the level of its use (country or corporate level).

The last type of categorization of academic research was used to summarize the current state of energy development in the crisis.

Čeryová et al. attempt to determine whether the 89 counties from different regions produce renewable energy efficiently given the investments made by public financial institutions and the installed electricity capacity for renewable energy sources. Stochastic frontier analysis and the Cobb–Douglas function were used to analyze different types of energy sources (hydropower, wind, solar, biomass, and geothermal). This type of analysis allows researchers to assess the competitiveness of countries and the efficiency of their energy markets. The primary results show the need to promote renewable electricity and public investment in the development of the energy market [11].

Melnyk et al. [12] use a narrower range of countries compared to [11]. A total of 36 OECD member countries were subjected to a socio-economic impact assessment and smart grid implementation using the panel list squares method.

The authors draw a paradoxical conclusion: the richer the OECD country, the less renewable energy sources were used. This statement is confirmed by the fact that the analyzed countries were mainly focused on the extensive use of traditional energy resources and neglected the sustainable development and the Millennium Development Goals [12].

The results of an investigation into 30 European countries in 2012–2020 is described in [13] which tested a hypothesis regarding the influence of energy efficiency and technological innovation on economic growth using data envelopment analysis (DEA). In the sample, most countries of Central and Eastern Europe saw a negative impact of the energy market developments on economic growth, especially on the innovation component of economic growth. However, in general, the positive impact of technology innovation on energy market parameters has been proven.

Ref. [14] describes the implementation of renewable energy innovation and technology in European households. In addition, the author emphasizes the role of a coherent and holistic low-carbon policy to support the penetration of renewable technologies into households, as opposed to a reimbursement policy to cover the electricity bills of vulnerable households. This recommendation for a change in EU policy could be a good solution to combat energy poverty and complete the energy transition.

The countries of the Visegrad Group (V4) are analyzed in the context of reducing poverty induced by the COVID-19 pandemic. The best practices for mitigating the impact of pandemics on energy market trends are summarized [15].

An additional focus on the costs of electricity generation in V4 countries in the light of their 100% renewable scenario is provided in [16]. Benchmarking the external costs of electricity generation supported by renewables using the ExternE methodology and the CASES database provides policymakers in the V4 with guidance on achieving a low-carbon transition by 2050. In the context of the joint optimization of CO2 emissions and progress in achieving a country's Sustainable Development Goals, possible energy solutions in the Norwegian maritime industry are considered [17].

The various problems mentioned in the development of the energy market are exacerbated by energy protectionism and energy dependence and even wars, which put great pressure on the existing energy supply chains, as well as the welfare of households and countries.

The Special Issue entitled "Financial Development and Energy Consumption Nexus" [18] is devoted to the most recent challenges in the development of the energy market and can be described as employing a level approach (country, corporate, separate technology on energy market) to grouping articles as follows.

Hajiyev et al. [19] investigated the influence of the energy dependence matrix of countries and the potential of 48 countries. The authors provide a detailed analysis of gas, energy, and oil wars between different countries (OPEC, EU, US, Russia, Turkey, V4, Baltic and MENA countries), describing peculiarities in their production, distribution, and consumption of energy resources.

Based on these peculiarities and the range of dependent and independent variables such as GDP, energy production and consumption, resource imports, industrial production, export, and energy intensity energy, a dependency matrix was created and three short- and long-term scenarios were presented in defining the influence of energy wars.

A total of 19 developing countries were chosen as objects of study using DEA analysis and assessment of the optimal energy distribution in the road transportation [20]. The authors analyzed different variables such as CO2 emissions, passenger-km and tones-km [20] to calculate the degree of countries' efficiency and inform the recommendations for managers and policymakers to make effective energy efficiency decisions.

Using the examples of 12 countries located in Eastern Europe, the Caucasus and Central Asia (EECCA), Trifonov et al. studied the impact of renewable energy sources on the energy security of countries. Medium- and long-term perspectives and non-linear optimizations techniques were used to test research hypotheses describing the role of increasing the share of renewable energy sources in the energy security and diversification of the EECCA countries [21].

Particular attention was paid to the development of the energy market of the EU countries. Chudy-Laskowska et al. researched the wind energy market in 28 EU countries in 2017 and grouped these countries in terms of their potential for wind energy production. The methodological basis of the study combines the Ward and Wroclaw methods for clustering procedures, as well as the TOPSIS method for ranking countries. The results of the study are important for identifying the main triggers for stimulating wind energy production in the EU [22]. Based on taxonomic analysis, 7 clusters of EU countries were determined by the level of their potential for wind energy development [22].

EU countries (especially euro area countries) were again the object of grouping based on the energy cost-effectiveness of their industrial sector in the work of Ginevičius et al. [23]. The authors proposed a universal methodology for comparing the energy development of countries and assessing the economic efficiency of the industrial sector, using a non-linear methodology instead of the currently preferred methodology of linearization and deploying homogeneous grouping instead of ranking.

In an earlier study [24], the development of energy in the EU countries in 2009–2018 was assessed in various areas applications, demonstrating agricultural, transport, service, and industrial application. As in the previous study, the authors tried to implement an alternative research methodology and assessed fluctuations in the energy development of these sectors (e.g., intensity and stability). The greatest development path was found both in industry and in the service sector [24].

Energy efficiency in the EU countries was observed in line with the policy of macroeconomic stabilization. An assessment of the impact of macroeconomic stabilization elements on decarbonization and energy efficiency was carried out in 1990–2020 for the five EU countries that are responsible for the most of greenhouse gas emissions. The OLS and SUR methods make it possible to prove the statistically significant influence of macroeconomic stabilization pentagon factors on green transition trends in the countries under study and to explain the importance of coordinating EU macroeconomic policy with environmental policy [25].

As an integral part of the EU energy complex, Poland has a special place in academic research on the development of the energy market, especially in terms of its financial aspects.

One features study [26] pays attention to assessing the impact of investments in renewable energy sources on the level of the sustainability of Polish provinces. This study had two focuses: transferring central government policies in this area to local governments and ranking provinces with a taxonomic measure of sustainability and renewable energy financing based on a linear order between the years 2016 and 2018. The authors tested how the financing of renewable energy sources in the provinces affects the level of sustainability of the province and how this interacts with environmental regulation [26]. However, the overall situation with renewable energy financing in Poland's provinces has improved between 2016 and 2018 and this factor has little effect on the level of sustainability of the province.

Another study is devoted to the financial aspects of the development of the energy market in Poland. Tarczyński et al. [27] formulate relationships between weather factors, stock market indicators, and investor sentiment from the point of view of behavioral economics. This study is based on the data obtained from energy companies from Poznan, Gdansk, Wroclaw, Konin, Warsaw, and Katowice which were included in the WSE listing in 2010–2020. The GARCH model was used to simulate the impact of weather factors on companies' stock market parameters. Positive modelling results illustrated the effect of weather factors on financial variables and discovered the opportunity to re-formulate investment strategies and make the investment portfolio more diversified [27].

The project level of financing in the Polish energy sector was assed in a study by Saługa et al. [28]. The authors estimated the discount rate for the evaluation of investment projects related to the coal-fired mode of power generation. The authors took into account the risk-adjusted discount rate, which is very important for the coal energy projects and illustrates the pragmatic approach to controlling risk factors in the energy decision-making process.

The basis of an effective solution for financing the renewable energy sector and progress in the field of sustainable development is up-to-date and reliable financial information that has been verified by auditors. Milojević et al. used the financial statements of Gazprom, E.ON, PNR, JTXG, and Santos since they are the largest companies in the energy sector. A methodology has been introduced to determine the length of the integrated audit vector to assess the impact of social responsibility factors on the quality of audits in these energy companies. The results of companies are different, ranging the highest quality for PNR to the lowest for Gazprom and E.ON. The reasons for financial auditing in the energy sector include the substantiation of the role of sustainability and responsibility of these companies [29]. Rabe et al. [30] studied the automotive industry in the EU and automobile manufacturing in the context of the EU Green Deal and the implementation of the EURO 7 standard.

Havrysh et al. investigated alternative energies and their role in the development of the energy market, examining the comparative competitiveness of biogas production in comparison with other types of renewable energy sources in the context of the biogas potential of Ukraine [31]. Cherednichenko et al. estimated the efficiency and CO2 emissions of the specific type of the alcohol-fueled regenerative gas turbine in the context of policy recommendations for local authorities on the effect of this technology on the environment [32]. In addition, Kut, Pietrucha-Urbanik, and Tchórzewska-Cieślak conducted a comparative assessment of photovoltaic installations in the Subcarpathian province, Poland, and the failure modes of these installations [33].

A specific technology has been modelled, as in previous studies, which was designed to stabilize the power networks with a hydrogen energy buffer. This model includes 49 variables derived from the hydrogen supply chain and utilities [34]. The study highlights the role of hydrogen from renewable energy production in the deployment of decarbonization technologies.

The major contributions of Danalakshmi et al. include the estimation and optimization of energy losses, and the development of a price management system using a self-balanced differential evolution (SBDE) algorithm based on 30 benchmarks. Particular attention was paid to blockchain technology in the process of modelling energy prices and ensuring security in microgrid architecture [35].

3. Conclusions

Assessments of market challenges, due to the ongoing energy crisis in and its discussion in academia, take multilevel perspectives, operating on the levels of the corporate, the national, stage of energy cycle, sector, energy resource type or technology used. The cross-country perspective remains the most popular. Comparisons of energy dependence, energy efficiency and energy security, the potential of alternative energy production, and the profitability of industrial and other sectors were carried out in the EU, Euro area, and V4 countries with aim of promoting the transition to a light green economy.

The financial aspects of energy market development play crucial roles in promoting decarbonization trends and sustainability values. The impact of investment in renewables on the level of sustainability of local authorities, the discount rate and risk parameter for coal-fired energy projects, as well as weather factors on investments in energy companies was proven based on Polish statistics, corporate data and listed company quotations.

Alternative renewable energies and technologies are shaping a new energy market architecture in times of crisis with highly competitive biogas and biofuel production, alcohol-fueled regenerative and hydrogen energy buffer technologies, capacity-building photovoltaics or country-specific renewable energy sectors.

Specific algorithms such as the SBDE algorithm, based on 30 benchmarks and blockchain technologies, bring new values for power loss optimization, energy price management and energy supplier transparency. Energy giants must adopt a deep financial audit focus to achieve greater sustainability and social responsibility transparency, and well-known automotive companies need to improve their environmental standards in line with EU requirements.

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