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Editorial

Renewable and Sustainable Energy—Current State and Prospects

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1. Introduction

The energy transition is seen as a fundamental engine of economic development and a factor in improving the quality of life [1,2]. World globalization is cited as a major determinant of the possibility of launching energy transition processes [3]. Through the creation of interdependencies between world economies [4,5], globalization processes have contributed to socio-economic change, the emergence of new institutions, and changes in the functioning of different markets. There have been significant changes in the labor market, changes in consumer attitudes, and an increase in business innovation, all of which have combined to allow revolutionary energy transition processes to take place [6,7].

Easy access to cheap energy is crucial for the economic development of a country [8]. Deposits of hard coal, oil, and natural gas are limited and non-renewable, which means that they are shrinking every year. Burning fossil fuels leads to greenhouse gas emissions, which results in ongoing climate change [9]. Therefore, it is necessary to increase the production of energy from renewable sources (RESs) and gradually increase the share of RE in the energy mix [10,11]. The ongoing energy transformation should take place in a sustainable and environmentally and human-friendly way [12]. The gradual development of RESs favors the creation of a decentralized society, powered by a network of smaller and safer RE power plants and the strengthening of local communities [13,14].

The energy transition occurs in various ways, e.g., changing energy sources to renewable ones or creating energy storage facilities, which helps ensure energy independence and stable energy supplies [15]. The transition to more sustainable energy sources such as renewable energy (e.g., solar, wind, geothermal) [16] helps to significantly reduce carbon dioxide and other greenhouse gas emissions [17]. Furthermore, by increasing energy efficiency, the energy transition contributes to reducing the overall energy demand, which is in line with climate policy goals to reduce the carbon footprint [18,19]. In this way, both spheres—the energy transformation and climate policy—complement each other and support the idea of sustainable development [20,21].

The dynamic development of the renewable energy sector requires the creation of a stable legal environment for conducting business in the field of energy management. In addition to reducing administrative barriers, the challenge of the Polish transformation is to harness the potential of wind energy, increase the flexibility of the power system, and optimize the use of available connection capacities to the grid. The development of energy storage is also crucial for the further development of renewable energy (RE). Energy storage allows for the real-world optimization of the use of electricity that is generated in micro-installations, which can be described as "postponing consumption in time". Surplus energy generated during the day should be utilized or stored to the maximum possible extent in order to utilize it in the evening and at night.

Received: 31 October 2024
Accepted: 26 November 2024
Published: 8 February 2025

Citation: Igliński, B.; Pietrzak, M.B. Renewable and Sustainable Energy—Current State and Prospects. *Energies* **2025**, *18*, 797. https://doi.org/10.3390/en18040797

2. A Short Overview of the Contributions to This Special Issue

This Special Issue presents an overview of the current status and development possibilities of cheap renewable and sustainable energy. Around the world, scientists, technicians, and energy engineers are conducting extensive research to improve different types of renewable energy. This entails the fact that RE technologies are characterized by increasing energy efficiency, while reducing investment and operating costs. There are also economic and social advantages of RE development, such as improved quality of life and new jobs, including in rural areas with high unemployment rates.

Recently, the share of renewable sources in the energy system has been increasing globally in order to reduce greenhouse gas emissions, mainly carbon dioxide. Lee and Joo [22] assumed in their study that it is possible to establish PV in areas with low energy demands and wind turbines in areas with high energy demands, which causes wind turbines to be characterized by higher investment costs than solar energy. However, the energy transmission costs for wind turbines are lower than those of PV generators due to the regional characteristics of the power grid, because RESs in high-energy-demand areas usually require much less additional energy infrastructure than in low-energy-demand areas. The results of this study show that the net benefit for wind energy is estimated at over USD 225 million, while PV brings a net benefit of almost USD 23 million. Sustainable energy development (SED) is the most important element of the Sustainable Development Goals (SDGs), which aim to maintain constant economic growth and social progress while protecting the environment and mitigating the effects of climate change [23]. SED serves as the current paradigm of sustainable development, providing a blueprint for energy development and economic prosperity.

In recent years, the solar collector and photovoltaic industry has been the fastest growing industry in the world. Gaudino et al. [24] built a high-pressure flat plate collector (HVFPC) using special solar absorbers to extend the application range of HVFPCs to 250 °C. The new performance model explicitly includes radiative heat exchange with the environment, which is the main source of thermal losses for HVFPCs at high temperatures. Radiative losses depend on the optical properties of the absorber, and other thermal losses are the result of the HVFPC architecture. Considering the meteorological data from 2019 in Cairo and a collector operating temperature of 250 °C, the annual energy production of the HVFPC equipped with the optimized absorber is estimated at 638 kWh/m^2. Assari et al. [25] conducted research on a cogeneration system producing electricity and fresh water. A parabolic trough collector, a reverse osmosis desalination system, and the Rankine cycle were used. The research results show that the maximum level of fresh water production occurs in June and July due to the increased solar radiation and ambient temperature.

In recent years, the share of PV in the global generation of electricity has been growing dynamically. In another article in this Special Issue [26], PV panels were assessed using the multi-criteria PROSA decision analysis method, supported by a stochastic approach based on the Monte Carlo method. As a result of the conducted research, it was concluded that the requirements of PV installations in households in Poland are best met by panels produced through Sino–Polish cooperation and in China. Polish-made panels were ranked lower, which means that they must be more technologically advanced. Bessi et al. [27] presented the current state and development prospects of the Italian photovoltaic market. A structural change was observed corresponding to the "reboot" period after the COVID-19 crisis. In Italy, there is a significant decline in prosumer PV due to the end of financial incentive programs. On the other hand, there is a very rapid, even exponential, growth of "large" PV panels.

Barbusiński et al. [28] verified the electrical parameters and durability of side connectors that are mounted in glass–glass PV modules. The resistance tests were in the GΩ range,

while for wet experiments, values in the MΩ range were obtained. In subsequent tests, the PV modules were subjected to environmental influences, and then, electrical measurements were taken again. A simulation of the effect of changing climatic conditions on the module test showed that the insulation resistance value decreases by an order of magnitude in both wet and dry tests.

Kuruvinashetti et al. [29] investigated the performance of microphotosynthetic power cell (μPSC) array configurations, including parallel, series, and their combinations in real time. They found that combinations of parallel and series μPSC arrays are more efficient in generating optimal power compared with configurations that use only parallel or series connections. The most important contribution of this study lies in the versatility and applicability of the proposed model for various array configurations, enabling a deeper understanding of the performance characteristics of μPSC arrays.

Farahat et al. [30] investigated the effect of ground albedo on the solar radiation received by surfaces that are mounted on constant south-tilted, single-axis and dual-axis arrays at 82 selected locations in Saudi Arabia. Zero ground albedo reduces the solar radiation levels by 1.43%, 3.50%, and 3.20% for the three modes, respectively. Therefore, a ground albedo of 0.2 can be used for most solar engineering applications without causing a loss of accuracy.

Solid biomass can produce energy and, especially in rural areas in Nigeria, can replace fossil fuels [31]. Currently, the country lacks a developed supply chain structure and has insufficient facilities. Investment and financial incentives, promotion of renewable energy sources, sustainable energy policies and energy transition plans, and legislative support are identified as factors that can accelerate the commercial production and adoption of solid biofuels in Nigeria.

Igbeghe et al. [32] investigated the use of biomass in both food and energy markets from 2010 to 2023, also tracking the impact of the COVID-19 pandemic. The authors identified regions that have made significant contributions and highlighted those that require more attention. Surprisingly, the observed annual growth rate of almost 11% indicates a potential decline in research output in this area. However, the sources identified in the study provide a valuable road map for further scientific exploration of the biomass–food–energy linkages.

Pyrolysis, like combustion, is a process that has been used in the human economy for many centuries. Currently, pyrolysis is an attractive alternative to the production of biofuels, sorbents, and chemical compounds. Igliński et al. [33] presented a review of the latest research on pyrolysis. The article describes the mechanisms of the pyrolysis process and the composition and properties of the obtained fractions, namely, biochar, bio-oil, and pyrolysis gas. In addition, technical and technological aspects of the pyrolysis process are presented, including the design and construction of reactors.

Chemical Loop Gasification (CLG) is an innovative double-fluidized bed gasification technology that enables the production of high-calorie synthesis gas from various solid raw materials (e.g., biomass) [34]. A key parameter of CLG technology is the circulation of solids between two coupled fluidized bed reactors to transport heat and oxygen, making the system hydrodynamics the basis of the entire gasification process.

In the field of RE, biological energy systems have emerged as key factors and are particularly suitable for low- and ultra-low-energy applications [35]. Microphotosynthetic fuel cells have the unique property of operating independently of organic fuels—in this, they differ from microbial fuel cells. They use the principles of photosynthesis and respiration to generate electricity in both light and dark conditions via water-splitting reactions.

Kovvuri et al. [36] assessed the risk of forest fires on power grids by considering historical forest fire occurrences, real-time forest fire proximity, and vegetation metrics.

Then, optimal weights based on principal component analysis were applied to formulate a new risk factor model. The model's suitability was verified through an empirical evaluation by selecting representative networks from different regions, which provided insight into the geographic variability of risk factors. Ultimately, this study offers stakeholders and decision-makers a comprehensive toolkit to make decisions on infrastructure investments, grid reinforcement, and strategic power redirection to ensure consistent energy delivery during forest fires.

Vamvuka and Tsilivakos [37] valorized unprocessed biochar from municipal waste (MSW) for energy purposes by means of its co-gasification with biochar from olive pits (OST) in a steam or CO_2 atmosphere. The co-gasification of OST with MSW (in proportions of 70:30) resulted in increased conversion, syngas yield, and calorific value of the produced gas compared with gasification of MSW only.

Biodiesel is a renewable alternative fuel to conventional diesel. In their article, Sambasivam et al. [38] reported the production of biodiesel from non-edible oilseeds, focusing on grain-based feedstocks. The authors presented the stages of grain separation and degumming, offering an in-depth analysis of the seed distribution. The necessary steps towards ecological biodiesel production were proposed, and the importance of integrating ecological and circular bioeconomy with biodiesel synthesis was emphasized.

The unique physicochemical properties and high octane number of alcohol (bioethanol) make it an ecological, alternative fuel for SI engines. Abdullah et al. [39] analyzed the properties of methanol, ethanol, and butanol fuels. The paper also discussed the emissions of pollutants such as CO, CO_2, NO_x, and UHC, as well as the exhaust gas temperature. Most studies showed that the combination of alcohol with gasoline resulted in a reduction in CO, NO_x, and UHC emissions due to better combustion.

Agricultural waste, including animal waste, can serve as a raw material for the production of biogas (mainly methane), which could be used as a RE source. Lovanh et al. [40] assessed the methane production from anaerobic reactors using different animal residues (e.g., dairy manure or poultry wastewater). The results showed that the CH_4 production increased with increasing temperatures and also with the type of feedstock used. A covered wastewater lagoon from the wastewater treatment plant achieved methane production of over 80%. Pilarski et al. [41] analyzed the energy conversion efficiency of a 1 MW agricultural biogas plant, in which the substrate was pig slurry, corn silage, or plant waste. Taking the results obtained from their analyses into account and using mathematical functions, the biomass conversion efficiency was determined as the ratio of chemical energy in CH_4 to energy in the substrates, which was close to 60%, with the efficiency of the cogeneration system being 35%. In turn, the total energy conversion efficiency associated with the production of electricity reached close to 28%.

Zielińska et al. [42] described organic transformation under anaerobic conditions and provided new information on the influence of some pollutants (e.g., pharmaceuticals) on sewage sludge fermentation. The operational parameters, environmental conditions, and microbial communities presented in the article can change the influence of pollutants on the fermentation process. Therefore, it is necessary to reduce the health and environmental risks associated with the reuse of fermentation waste.

Archimedes' screws were known in antiquity and were used for pumping. These screws can be successfully used for electricity production. An article included in this Special Issue [43] presented both experimental results and numerical simulation data based on research on screw generators of a wide range of sizes (from laboratory scale to large-scale power plants).

The shortage of energy and water resources and the rise in temperatures caused by global warming have led to measures to improve the energy efficiency of power plants'

thermodynamic cycles to adapt them to lower energy consumption and operation at higher temperatures. Meana-Fernández et al. [44] presented an overview of thermodynamic cycles for energy production, from Brayton to Rankine and combined cycles, alongside specific cycles such as organic Rankine, Kalina, Goswami, or the recently developed hygroscopic cycle. The most important factors for each type of cycle were analyzed, and the most sustainable options were identified in terms of resource consumption, as well as future prospects, in order to ensure their energy efficiency and sustainable development.

Badea et al. [45] reported that lithium-ion batteries are the most suitable candidates for "replacing" fossil fuels due to their technological efficiency and operational safety. These devices have the advantage of facilitating the transition to electric-vehicle-based transport and therefore to a circular economy and zero pollutant emissions in the years to come. The development and testing of new materials and technologies that can replace fossil fuels contribute significantly to reducing the negative effects of pollution, improving real-life conditions and promoting the conservation of natural resources for future generations. Suitable for solid-state and sol–gel synthesis, they were chosen as facile methods for preparing lithium-rich cathode material for lithium-ion batteries [46]. From the extended family of layered oxides, $Li_{1.2}Ni_{0.2}Mn_{0.6}O_2$ was selected due to its low nickel content and lack of cobalt. The solid-state synthesis allowed the authors to obtain better structural properties compared with the sol–gel synthesis in terms of a well-formed hexagonal layered structure and reduced Li^+/Ni^{2+} disorder. Conversely, the sol–gel method produced a material with higher specific capacitance. The performance of the latter material was then evaluated as a function of the discharge current.

González-Muñoz et al. [47] conducted a study on RE project valuation, proposing a method for estimating the volatility of new and RE projects, which is based on the concept of implied volatility for financial options. The debt-to-equity ratio for real options is used in place of the strike price or cash value that is used in financial transactions. Therefore, the natural spline model is used to calibrate implied volatilities. The primary advantages of the implied volatility model (for financial options) are its ability to provide more accurate results, as well as its widespread acceptance among energy experts and academics.

Kampik et al. [48] presented sample results of their research on the influence of individual current harmonics on the indications and errors of selected energy meters. Detailed studies showed that selected energy meters were resistant to the typical spectra of distorted load currents and did not show excessive measurement errors. Continuing similar studies seems to be advisable in view of the common use of electronic energy meters, especially in electricity billing and distribution systems.

Possible applications of drainage water (DW), which is obtained during soil-less plant cultivation, requires a large input of energy. It should be emphasized that DW is characterized by high electrolytic conductivity and high redox potential; it is also stable and does not rot. Mielcarek et al. [49] used the physicochemical properties of DW for its biopurification using an external organic substrate in the form of citric acid to recover energy using a microbial fuel cell. The adopted solution required only the connection of electrodes and tanks with an ion-selective membrane. Future research should focus on the biological processing of melting waste and on determining the feasibility of energy recovery using similar cells.

Another paper in this Special Issue [50] describes a passivity-based study for estimating the radiation transfer function that accurately replaces the convolution operation in the Cummins equation while preserving the physical properties of the radiation function. It is worth noting that a two-step numerical optimization approach is used, where the first step uses readily available algorithms to fit the radiation attenuation transfer function matrix to the radiation frequency response of the system. The second step imposes

additional constraints on the form of the transfer function matrix in order to increase its passivity index.

Kampik et al. [51] assessed hourly energy consumption profiles in railway signal boxes in Poland. Their study involved determining the correlation between the hourly demand profile, and weather and calendar indicators (e.g., month, week, cloudiness, and temperature). The time of day and ambient temperature have the greatest impact on the profile. The correlation coefficients were obtained by comparing the energy demand profile with the previous day. In this case, the Pearson and Spearman coefficients for all the analyzed facilities ranged from about 0.7 to about 0.9.

Sustainable development also includes housing. Attention should be paid to the heating of utility water, because the share of this type of heating in the energy balance of buildings is constantly growing. One of the methods used to reduce energy consumption for water heating is heat recovery from gray water. The aim of a study in this Special Issue [52] was to assess the possibility of improving the efficiency of a circular horizontal water drainage unit by using baffles. It was shown that the efficiency of the unit equipped with a DWHR without baffles was increased. This result can be used by companies that want to introduce new equipment and technologies into the market.

Pérez et al. [53] demonstrated the atmospheric stability of the coastal region of Yucatan, Mexico, using the wind shear, turbulence intensity, Richardson number, and Monin–Obukhov length. They found that variable atmospheric conditions provide up to 8% more wind power than stable conditions. In contrast, neutral conditions provide up to 9% more power than stable conditions.

3. Conclusions

To sum up the previous reflections, it should be stated that energy transformation is no longer a choice, but a necessity. Today, we are not asking whether, but how quickly, we will achieve climate neutrality owing to zero-emission technologies. Further development of renewable energy is inevitable, which is why each country should strive to create the best possible conditions for both professional investors and smaller recipients: citizens, local governments, cooperatives, and entrepreneurs. This determines how quickly cheap, green energy will power households and industry.

This means that in the coming years, we will witness the systematic development of energy transformation processes. This will also mean further dynamic development of the RE sector in terms of all potential renewable sources. It should be emphasized that in modern world economies, the renewable energy market is particularly important, because it will ensure energy security at the macro-regional level.

It should be emphasized that the challenge from the point of view of the RE market is to measure the spatial development of individual renewable energies. There are tools, such as gravity models or taxonomic development measures, that allow for the assessment of the potential of a selected phenomenon related to renewable energy while taking spatial considerations into account [54]. Using these tools will allow for the monitoring and assessment of the development of the renewable energy market, which may allow for more effective state energy policies in this area. Finally, attention should be paid to the emergence of new start-ups that are involved in green energy and sustainable development [55]. Undoubtedly, such companies should have state support or institutional conditions for competitive development, because they are often the ones who create revolutionary solutions in the field of energy transformation processes. It is also suggested that it is necessary to provide institutional conditions for the possibility of obtaining funds from the stock exchange by start-ups that have achieved market success [56]. The possibility of transforming such en-

terprises into joint-stock companies may constitute both the next step in their development and an incentive for the establishment and entry of other such companies onto the market.

Author Contributions: Conceptualization, B.I. and M.B.P.; methodology, B.I.; software, M.B.P.; validation, B.I. and M.B.P.; formal analysis, B.I.; investigation, M.B.P.; resources, B.I.; data curation, B.I.; writing—original draft preparation, M.B.P.; writing—review and editing, B.I. and M.B.P.; visualization, M.B.P.; supervision, M.B.P.; project administration, B.I.; funding acquisition, M.B.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflicts of interest.

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