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Editorial

Renewable Energy Systems 2023

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1. Introduction

In the last few years, the adoption of renewable technologies and energy efficiency strategies has become increasingly pivotal for reaching the ambitious target of an 80–95% reduction in greenhouse gas emissions by 2050 [1]. In order to find a sustainable balance between the production and consumption of energy, and reach those targets, several challenges still need to be addressed. These problems are strongly related to the increasing demand for energy [2] due to the development of both industrialized and emerging countries [3]. As such, several countries have agreed on the necessity of developing and implementing a novel sustainable energy paradigm in the building, transport, and industrial sectors. For this reason, novel pillars of development for the future and a sustainable energy system have to be varied and flexible, such as the waste to energy paradigm [4], a reduction in energy consumption, the circular economy [5], improved quality of life for people [6], pollution and climate change adaption [7], carbon neutrality with the overall goal to reach zero emissions by 2050 [8], etc. To increase the penetration of renewable energy into society, significant care must be taken with issues related to the management of the excess production of renewable electric energy [9], which leads to several severe issues in terms of grid management [10]. The increasing development of power-to-x technologies [11,12] will be crucial to mitigate the phase shifts between renewable energy production and user demand [13]. In this framework, the reduction in energy waste through feasible waste management approaches is also crucial [14]. Not only this provides a renewable source of energy from low/negative-value wastes in the form of heat, electricity, or fuels, but it also minimizes environmental pollution due to a reduction in the volume of waste produced by leading to an increase in the reuse and recycling of waste materials [15]. The use of electric vehicles powered by renewables will significantly influence the reduction in GHG emissions from the transport sector [16].

To develop and support this new approach to energy use and production, scientists and companies have focused their attention on the use of renewable energy technologies, improved functional energy use, energy efficiency, novel efficient energy conversion systems, etc. In this context, this Special Issue "Renewable Energy Systems 2023" aims at summarizing the most up-to-date advancements and central studies dealing with the integration of renewable technologies into new or existing systems for the production of energy and non-energy outputs. In this editorial, the presented papers within the Issue are summarized, spanning the potential use of renewable energy for power production, heating, cooling, water management, and transport. The contributions of the main works in this Special Issue within the above mentioned framework are presented and discussed, using the method outlined in the following section.

2. The Research Topics Represented in This Special Issue

A total of 10 papers were selected for this Special Issue. The main ideas of these papers are briefly reviewed in the following subparagraphs in order to summarize all the presented research. As such, this editorial has been organized into the following sections:

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Section 2.1, power plants based on solar systems; Section 2.2, power plants based on wind systems; Section 2.3, power plants based on biomass sources; and Section 2.4, other topics.

2.1. Power Plants Based on Solar Systems

Calise et al. [17] developed a dynamic simulation study on the operation of a greenhouse coupled with renewable energy technologies. The paper is focused on the design of the system components in order to dynamically investigate the operation of this hybrid renewable energy plant. The plant is considered an optimal solution within the green farm framework. In particular, a 20 kW photovoltaic (PV) field is considered adequate to supply the electric energy demand of the farm, in addition to 28 m^2 solar thermal collectors which are designed to meet the thermal energy demand of the greenhouse when its operating temperature falls lower than a specific set point. A biomass auxiliary heater is also included. The plant is designed to produce electricity for buildings close to the greenhouse, their related irrigation pumps, and thermal energy both for the greenhouse's heating and the domestic hot water and space heating energy demands of users in the nearby buildings. As part of a bio-circular economic approach, the plant also includes a pyrogasifier fueled by wood and agricultural waste. This model is applied to a specific case study; a green farm located in Naples (southern Italy). The operation of the whole plant, the energy components, and the greenhouse are dynamically simulated in TRNSYS 18 software. The greenhouse's thermal behavior is also validated using the values in the literature. Subsequently, a detailed energy, economic, and environmental analysis of the whole plant is performed. The proposed plant is able to reduce its total equivalent CO_2 emissions by 148.66 t/y. In addition, it obtains good profitability, with a simple payback of only 1.7 years. Božiková et al. [18] presented a simplified mathematical model for the evaluation of the energy production of a PV field, as a function of its tilt angle and azimuth angle. The authors state that the developed model is useful for ordinary users of PV systems, considering the model's very small number of input parameters. The key objective of this study is the identification of the optimum locations of PV fields, considering the local weather in southern Slovakia. In their work, an experimental system based on two polycrystalline PV modules is also used. In particular, the first part of this experimental system identifies the tilt angle variation, from 0 to 90. The second module aims to calculate energy production as a function of the azimuth angle. Using the carried-out measurements, regression equations highlighting the relationships between the tilt or azimuth angle and the energy produced by the PV system are generated. Although the presented models are obtained for an area of southern Slovakia, these models, described by a simple second-degree polynomial function, can also be considered applicable to the further areas in Central Europe, if the regression equation coefficients are suitably modified. The presented mathematical model is about 4% more precise than other models used for this weather zone in southern Slovakia. Combining their analysis of the results achieved through their experimental and numerical simulation approaches, the authors found that the effect of the tilt angle and azimuth angle of a PV module on its electricity production is about 18% and 24%, respectively. This mathematical model allows for a simple forecast of PV production in real operating conditions in southern Slovakia for design, dimensioning, and optimization purposes. Pintanel et al. [19] investigated the integration of thermoelectric generators (TEGs) into these photovoltaic and thermal collectors (PVT) in order to increase their power production. They performed an experimental and numerical comparison between a PVT panel with and without TEGs. The authors state that the novelty of the presented work is due to both the numerical and experimental analysis they performed on this kind of system. The aH60 model manufactured by Abora Solar was used to perform the analysis. This includes an isolation layer at the back and an isolation camera monitoring the argon in the front layer of the panel. In the layout with the TEGs, the PVT panel included 19 integrated TEG modules in the bench test. The experimental setup also included an isolated 197 L water tank; an impulsion pump; temperature, irradiation, and mass flow probes; an expansion vessel and an aerothermal vessel; a 500 W microinverter; and the electrical panel of the bench. The 3D numerical model of the system was validated with their experimental results, demonstrating the good agreement between the simulated and experimental results. However, the errors in the results were smaller than 10%; therefore, the authors stated that the integration of thermoelectric materials within the PVT panels should be further researched to improve the contact region between both sides of the TEG devices. Their numerical analysis results indicate that the global efficiency of a conventional PVT panel is 81.9%, and the global efficiency of a PVT+TEG panel is 82.2%

2.2. Power Plants Based on Wind Systems

The efficient utilization of renewable energy sources and, in particular, of wind energy, is one of the key strategies to reach the objectives of the 2030 Agenda and the Paris Agreement and reduce CO_2 emissions. For this reason, it is necessary to focus our research efforts on the developments in wind energy projects. It is in this framework that the work of the Murgas et al. [20] was developed. In particular, this work is a literature review which evaluates the models and approaches used in the evaluation of investments in wind systems under uncertainty. In total, 97 studies were evaluated, with 20 different approaches or models detected and grouped into eight different categories, namely, (1) real options, (2) optimization, (3) stochastics, (4) financial evaluation, (5) probabilistic, (6) estimation, (7) numerical prediction, and (8) others. The real options approach, in which the events featured in the possible outcomes are not known, and, therefore, their probability of occurrence cannot be quantifiable, is typical for wind energy systems. In particular, they found that this approach is used in 32% of studies (31 publications). Of the studies adopting the real options approach, 62.5% of them considered the price of electricity to be a source of uncertainty, as did 15.6% with the feed-in rates-subsidy, and 18.8% with the velocity of the wind. The authors stated that future studies should focus on the evaluation of investments in wind energy projects, investigating the real options approach and public opposition to the projects (including NIMBY projects: not in my backyard). A methodology to represent the synthetic inertia of wind turbines as part of an optimization dispatch model is presented in the work of Thiesen and Jauch [21]. They investigated synthetic inertia because it is a crucial element to guaranteeing the stability of power systems, as it limits the speed with which the grid frequency changes. Frequency-converter-connected generation units such as wind turbines do not have an inherent inertial response. WTs and PVs decrease the synchronous inertia in energy systems. The trend of decreasing system inertia is not reflected adequately in current unit commitment and economic dispatch models. However, variable-speed wind turbines, already in use, are a source of synthetic inertia. For this reason, a unit commitment and economic inertia dispatch model of the all-Island Irish power system is used as case study in this work. This case study is selected because the current all-Island Irish power system is already characterized by high amounts of frequency-inverter-connected penetration. The potential of wind inertia is analyzed and calculated, revealing that the synthetic inertia provided by wind turbines is able to save up to 30.99% of CO_2 emissions, reduce curtailment by up to 39.90%, and reduce system costs by 32.72%.

2.3. Power Plants Based on Biomass Sources

The production of biogas from anaerobic digestion processes that start in wastes is a relevant topic in the current energy framework, and it fulfills the goals of the green circular economy [22]. In the work of Obileke et al. [23], a wide-ranging literature review is presented, focusing on the most recent advancements in anaerobic digestion and gasification technology for the sustainable waste-to-energy paradigm. The methodology followed is a conceptual review, which contributes to a better understanding of the topics discussed. The technologies are investigated and analyzed both separately and as a whole hybrid system. The literature review included the most recent studies dealing with the latest developments of these technologies, the intensification of these processes, the supply of several feedstocks, and the quality of the final biogas or syngas obtained. According to the analysis provided, several factors affect the final yield of biogas or syngas. The most influencing factors on anaerobic digestion are the operating temperature and the pH of the biomass. For the gasification process, these instead are the moisture content of the biomass and the gasifying agent used. These parameters also affect the quality of the gas produced, in terms of its lower heating value (LHV). For instance, in the case of gasification with air as the gasifying agent, the LHV is roughly 4–6 MJ/Nm^3, whereas in case of oxygen it is nearly 17–18 MJ/Nm^3, i.e., roughly four times higher. Of course, the selection of the gasifying agent is also dictated by its cost, therefore an optimal solution must be found. However, it was found that both these technologies are effective for energy recovery, with the need for enhancers and intensifiers to improve the efficiency of conversion. The relevance of this work in the current energy framework lies in its potential for global implementation, offering a sustainable approach to waste-to-energy generation.

2.4. Other Topics

Other relevant works in this Issue propose innovative solutions for the energy inefficiency in other energy sectors. In Rodriguez-Estrada et al. [24], the development of a novel microgrid architecture, the modeling of power converters, and the design of a hierarchical control system, including an innovative energy management system (EMS), is proposed. The work presents a novel multibus multivoltage architecture for the application of direct current microgrids to buildings. The aim is to increase the efficiency and the flexibility of power distribution systems by means of modeling and designing these systems using Petri net theory. The results validated each version's performance in a closed loop, with a feedback state controller as the local control stage for every converter in stand-alone operation. The results obtained can set the stage for the further development of finalized microgrids that improve aspects of the environment and the economy. In Sergienko et al. [25], the authors developed a mathematical model for an innovative clutch control mechanism that featured higher energy efficiency and higher performance in terms of the transmission system. Moreover, in this work, it was numerically proven that an equal loading for the frictional discs of each clutch is not guaranteed when there is a radial movement of the carriage when switching on the clutches. This contributes to the increasingly uneven dynamics of torque and disc wear. The results of the synthesis showed that the carriage movement partially depends on the force acting on the pressure disc. In particular, the minimum carriage movement is defined by the wear resistance of the mechanism, determining an inclination angle of the surface profile of the platter between 20 and 29°. This dual-clutch transmission (DCT) system is mainly proposed for the automotive sector, but the results obtained in this work can be extended to several energy system sectors. Qureshi et al. [26] developed a comparative analysis of numerical models in the field of decision-making processes, aiming to highlight the main limitations of several multi-criteria decision methods (MCDM) in terms of the reliability of their decisions. More specifically, these tools are applied to the selection of urban heat mitigation measurements with specific criteria. This numerical investigation allowed for the evaluation of the reliability of diverse MCDMs that adopt the same decision matrix and different normalization techniques, showing the impact of the analytic hierarchy process (AHP) on the decisions made. Of the techniques analyzed, the weight sum method and preference ranking organization method for enrichment evaluation were revealed to be the most reliable. Kadochnikov et al. [27] provided discussion on a non-standard experimental setup developed in the laboratory of the St. Petersburg Mining University's Well Drilling Department. The technique presented allows one to simulate the well cleaning process of making cuttings by evaluating the variations of the parameters that cause buckling, such as the zenith angle of the well or the rotation frequency. Statistica 13 and MS Office Excel software were used for mathematical analysis. The key finding of this work is that a controlled buckling of the drill string significantly enhances mud plug breakdown and well cleaning, especially at critical zenith angles such as 55 degrees. The relevance of this work lies in its assessment of the enhanced efficiency and safety in petroleum engineering, especially in directional drilling operations.

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