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Editorial

PV Tracking Systems

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Dramatic climate change has been well-observed for several years, mainly due to the effects of pollution caused by the burning of fossil fuels. The exhaustion of fossil energy resources also represents a major issue for humankind. Research in the field of renewable energy systems (RES) is a worldwide priority because green power "plants" can provide long-term environmentally friendly solutions. The Sun is the most important source of renewable energy, both directly and indirectly. Increasing the energy efficiency of solar-energy-conversion devices (for electrical or thermal energy) is a continuing interest and challenge for contemporary research.

Two technologies are currently used to produce electric power from the Sun, concentrated solar power (CSP) and photovoltaic (PV) technology, the latter being addressed in this Editorial. The efficiency of photovoltaic conversion depends on the type of solar cells, their temperature, and the amount of incoming solar radiation. The last can be maximized by using Sun-tracking systems (solar trackers). To paraphrase an old Maori proverb, "Turn your face to the sun and the shadows fall behind you"; the theme of this Special Issue of *Energies* can be rendered as follows: turn the PV module to the Sun and the shadows fall behind it. Adding solar trackers to PV systems can increase their energy efficiency by 20–50%, relative to that of the equivalent fixed (stationary) systems, depending on the type of tracking mechanism (its number of degrees of freedom), the control strategy, and the climatic conditions.

A comprehensive systematization of PV tracking systems should consider the operating principle (i.e., passive and active systems), the number of degrees of freedom, the relative positioning of the rotation axes, the type of control system, the number of monitored/controlled parameters, the number of modules simultaneously oriented, and their arrangement (individual modules, strings, platforms, or string platforms). The evaluation of the behavior and efficiency of PV tracking systems is addressed in this Special Issue, with both theoretical and experimental models. The increasingly frequent use of modeling, simulation, and optimization tools in virtual environments is also noted.

This part briefly discusses each of the eight articles published in the main text of this Special Issue, starting with the seven research papers, arranged in the order of their publication, and ending with the review article.

In [1], a sliding control was designed to regulate the PV modules' output voltage and make the panel work at the maximum power voltage. This control was selected to improve the robustness, transient dynamic response, and time response of the system under changeable environmental conditions, adjusting the duty cycle of the DC/DC converter. Additionally, a remote sliding control was developed to conduct the global supervision of the PV system in distributed generation grids. The proposed algorithm was tested in an experimental setup/platform containing three PV modules, connected both locally and remotely to the base station, and the system proved to be effective in both communication modes.

The research described in [2] conducted a study on the influence of the solar position calculation methods applied to horizontal single-axis solar trackers on energy generation. The energy output of the PV module was estimated by considering six representative algorithms for the computation of the Sun's position, including the five algorithms originally developed by Grena, as well as the solar position algorithm (SPA) proposed by Reda and Andreas. The results reveal that any of the six studied algorithms can be used without incurring relevant errors in the estimation of the energy generated by the PV system. In these conditions, it is recommended to use those algorithms that are less complex and faster, such as Grena 1 and Grena 2.

In [3], a new hybrid maximum power point tracking (MPPT) method was designed by combining a modified grasshopper optimization algorithm (GOA) with incremental conductance (IC), with the purpose of accurately finding the global maximum power point (GMPP), with a short tracking time. Experimental tests were carried out for evaluating the effectiveness of the proposed method compared to some representative existing MPPT algorithms, such as particle swarm optimization (PSO) and the modified firefly algorithm (MFA). Six different power–voltage curves with different GMPPs (single peak, left-side peak, left-middle-side peak, middle peak, right-middle-side peak, and right-side peak) were tested, showing that the proposed method ensures the highest tracking efficiency and lowest tracking time.

The study in [4] addressed the optimization of a dual-axis azimuthal solar tracker for a PV platform. The tracking mechanism used linear actuators as actuation elements for both movements (diurnal and elevation). In the case of diurnal movement, a slider–rocker linkage was used for amplifying the actuator's stroke and avoiding the risk of the system locking itself. The optimization study targeted the mechanical device, the control device, and the biaxial tracking program, with the purpose of obtaining a high input of solar radiation, with minimal energy consumption to achieve tracking. The study was carried out by using a virtual prototyping platform; the results of the simulations, which were performed for a set of representative days throughout the year, proved the effectiveness of the proposed design.

An innovative control system based on the emperor penguin optimizer (EPO) is proposed in [5], with the purpose of optimizing the parameter of the boost converter used for MPPT. In addition, the proposed EPO algorithm was utilized to optimize the gains of the proportional–integral (PI) controller used for the grid-connected inverter to regulate the DC-link voltage. The performance of the proposed EPO algorithm was compared with that of particle swarm optimization (PSO) and the cuttlefish algorithm (CFA) under different partial shading patterns and dynamic changes in irradiance levels. The PV system undergoing partial shading, which consisted of two PV arrays, each composed of 3 series modules and 66 parallel-connected strings, was modeled and tested by using MATLAB/Simulink.

In [6], a smart solution for characterizing the outdoor performance of a PV module is proposed. This solution uses a robust, lightweight, portable, and economical outdoor test facility (OTF) with Internet of Things (IoT) capability. The approach is based on the capacitive-load-based method, which offers improved accuracy and cost-effective data logging using Raspberry Pi, and enables the OTF to automatically sweep during the characterization of the PV module. The integration of the IoT with the super-capacitive load-based method provides an advantage of remote database logging with automated standardized calculations for quality assurance and performance determination. Experimental tests showed that the overall maximum accuracy realized by the proposed capacitive-load-based OTF was higher than that of the conventional resistive method.

The research in [7] focused on evaluating the energy output of a single-axis polar mount tracking system (without concentration) when the tracking error was conveniently increased according to strategies created to accomplish their tasks. The novelty of this approach comes from a model that simplifies the electromechanical solar tracking system, which translates into a reduction in the cost of the operation/maintenance of a single-axis solar tracker. It also offered ways to minimize, by the appropriate choice of the number of discrete positions, the loss of the collected solar energy in a single-axis polar mount.

Finally, [8] is a comprehensive review (based on 109 bibliographical references, most of them published in the last 10 years in mainstream journals in the field) of state-of-the-art research and literature on PV tracking systems for the production of electrical energy, as well as the latest studies that have been conducted in recent years. PV tracking systems are classified based on various criteria, such as the type of driving system (active and passive systems), the number of degrees of freedom (single-axis and dual-axis), and the type of control system (closed-loop, open-loop, and hybrid control). The specific advantages and disadvantages of each solution are discussed, and the most important findings are highlighted.

The design and optimization of PV tracking mechanisms are of continuous interest and remain challenges for research, considering the major impact they can have on the energy efficiency of systems for converting solar energy into electricity. Although the vast majority of the specific aspects appear to have been addressed in sufficient detail in the literature, there are still opportunities that deserve to be explored in further research. One of these is more in-depth research into adaptive tracking systems, which should be able to make tracking decisions based on real weather conditions (including external disturbances, such as wind action), and also relying on meteorological forecasts. Another important research direction is the development of solutions and strategies to avoid the overheating of PV modules, which dramatically decreases their efficiency. Finally, it is necessary to deepen research into the design of innovative combined tracking and wiper mechanisms, which, in addition to their main function (that of monoaxial or biaxial orientation, by case), can also clean the PV module's surface (without the need to use a supplementary/separate actuating source), best maintaining the conversion efficiency of the PV module.

This Special Issue is composed of seven research papers and one review paper on various topics and methodologies related to PV tracking systems. The contributors have shared many valuable insights into recent developments and beyond. The guest editor has briefly summarized the details of each paper, as well as highlighting three directions of emerging topics (as research opportunities) in the field. The guest editor would like to express gratitude for the contributions of all the colleagues and reviewers who were involved in this Special Issue. We hope to witness many implementations of innovative PV tracking system designs in the RES industry in the near future.

Conflicts of Interest: The author declares no conflict of interest.

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