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Opinion

Photovoltaic (PV) System Power Generation Performance Advancement

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Opinion

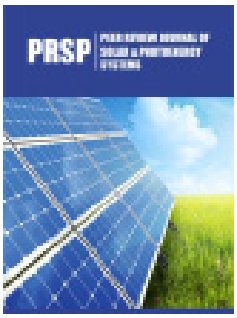
Fossil energy is limited and easy to pollute the environment. Therefore, it is necessary to conduct research on new energy. Among the new energy sources, solar energy has the characteristics of being clean, renewable, and benefiting from one-time investment for life, which has attracted widespread attention. In the 21st century, improving energy efficiency and optimizing the energy structure have become the key to global sustainable development.

Gabriele Zini et al. proposed methods of fault tree analysis and probability to analyze the impact of each component on the system to promote effective monitoring and safe operation and maintenance of the system. Marcelo Gradella Villalva et al. put forward the expression of diode saturation current (I0) and temperature, which reduces the error caused by the previous estimation of I0. Pei Tingting and others established a dynamic model of the photovoltaic array and conducted experiments under the worst weather conditions of the year in Jiuquan, Gansu, and concluded that the output power of the dynamic model under PSC is close to the output power under unshaded conditions.

The material of the solar panel is related to the photoelectric conversion efficiency. The conversion efficiency of polycrystalline silicon is slightly lower than the 1% conversion efficiency of monocrystalline silicon, but the energy consumed in the manufacturing process is about 30% less than that of monocrystalline silicon, so polycrystalline silicon is more economical. Brijesh Tripathi et al. collected annual electricity production data for polysilicon power plants and amorphous silicon power plants in Gujarat, western India, under actual climatic conditions and conducted performance evaluations. The research has concluded that the power generation efficiency of polysilicon power plants is higher.

In the PV system, the most direct way to improve the conversion efficiency is to maintain the strongest light intensity on the panel. Mosher et al. proposed to add an optimized solar tracker to the PV system. When the number of photons received at both ends of the cadmium sulfide photoconductor is the same, the tracking controller does not work. The tracking controller works and drives the solar panel to move in the direction of the sun until the number of photons received at both ends of the tracker is the same. Experiments were conducted under clear weather conditions, and the system containing the tracker was 30% more productive than the system with fixed panels.

The structure of the photovoltaic array affects the photoelectric conversion efficiency. In 1990, Salameh et al. still proposed the electrical array reconfiguration controller (EARC) method for the first time, using switches, sensors, and controllers to dynamically change the PV array connection structure to increase the system's impact on the PSC. This method is used in a PV-powered water pump system to improve the performance of PV power supply. Dzung Nguyen et al. proposed that EARC is suitable for the situation where the number of rows of the photovoltaic array is small, otherwise a large number of switches are required, which makes the structure more complicated. Subsequently, scholars respectively proposed the following reconfiguration structures, such as SS, PS, TCT, SP, BL, HC structures and so on. Guillermo Velasco-Quesada et al. used a 1.65kWp small grid-connected PV system as an example to study the EARC method to further prove the effectiveness of EARC.



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Weidong Xiao et al. proposed a grid-connected topology, so that each photovoltaic module is equipped with a power interface to connect with a DC/DC converter and a maximum power point tracking (MPPT) module to supply power to the DC bus. This method enables each individual module to work at its optimal operating point, that is, the output of the system is only affected by defective modules. They also compared the components and modeling performance of the boost topology and the buck topology, and finally concluded that the Boost converter has better damping characteristics. The output power in the grid-connected PV system is limited to a specific value of Flexible Power Point Tracking (FPPT). In order to solve the problem of slow dynamics of traditional FPPT, Hossein Dehghani Tafti proposed an adaptive FPPT algorithm, which determines the reference value of output power by calculating the reference voltage of the battery panel. Experiments on a 3 kVA grid-connected single-phase photovoltaic system have proved the fast dynamics and high precision of the algorithm under various operating conditions.

The key technology to maximize the power generation efficiency of a given photovoltaic cell is MPPT. Because the mathematical model under PSC is nonlinear, the traditional MPPT control method is no longer applicable. The method of turning multiple peaks into multiple single peaks is not applicable due to poor actual results. And artificial intelligence algorithms such as particle swarm optimization (PSO), simulated annealing algorithm (SA), genetic algorithm (GE), differential evolution algorithm (DE), etc. have a strong guiding significance for nonlinear problems. At present, scholars are focusing on combining artificial intelligence algorithms with traditional algorithms or combining multiple intelligent algorithms.

The algorithm is constantly improving. Taking the PSO algorithm as an example, Miyataki et al. introduced the standard PSO algorithm in the MPPT. Although the maximum power tracking can be achieved in the dynamic situation of partial shade, the particle trajectory in the standard PSO algorithm is limited by its acceleration. If the acceleration is too small, the trajectory will not fall into the local optimum, but the algorithm will take a long time; on the contrary, if the acceleration is too large, there will be a problem of poor convergence. In view of the shortcomings of standard PSO such as insufficient convergence speed and low search accuracy, scholars have conducted more in-depth research on this algorithm. Yuan Xiaoling and others proposed an adaptive perceptive PSO (APPSO), which introduces nonlinear dynamic inertia weights, and continuously modifies the particle's perception radius and search direction during the iteration process, which can effectively improve the algorithm's global search capability, but it increases the system burden. Wang Shuohe et al. proposed an improved PSO algorithm based on individual position variation. By introducing nonlinear variation mutation operations into the particle swarm algorithm, the particles that meet the mutation conditions are mutated, and the tracking speed is significantly improved. The search range of the particles is calculated, and the experimental results show that compared with the traditional PSO method, the improved method can track the maximum power point under any conditions.

The combination of multiple algorithms is not uncommon. Sridhar R et al. proposed a DE-PSO algorithm combining DE and PSO, which can accurately find the global maximum power point, but the convergence speed is relatively slow. Due to the excessive jump of the duty cycle of the MPPT, the circuit will produce severe instantaneous spike voltage and ringing, which greatly reduces the reliability of the system. Neeraj Priyadarshi proposed a hybrid MPPT method based on adaptive neuro-fuzzy inference system-particle swarm optimization (ANFIS-PSO), which can measure irradiance and temperature variables without additional sensors. The proposed grid-connected photovoltaic system experiment was carried out in MATLAB. The research shows that the convergence speed of ANFIS-PSO is faster than that of PSO. Jinhua Liu et al. proposed an algorithm that combines PSO with the traditional incremental conductance algorithm (IC). These two algorithms learn from each other's strengths. Due to the strong global search capability of the PSO algorithm, they work under changes in the external environment, while IC works under stable external conditions. This type of algorithm improves tracking accuracy and speed and reduces hardware costs.