Секція 8.
ЕКОНОМІКА СІЛЬСЬКОГО ГОСПОДАРСТВА

Abdraouf NAMOUNE
Semi-Conductor Laboratory, Badji Mokhetar University Annaba, Algeria
e-mail: raouf.namoune@gmail.com

OPTIMIZING SOLAR PUMPING SYSTEMS FOR SUSTAINABLE AGRICULTURE: PERFORMANCE ANALYSIS AND RURAL APPLICATIONS

Renewable energies such as solar, wind and biomass have become indispensable solutions to the energy challenges facing the agricultural sector. Not only do they contribute to environmental sustainability, they also reduce long-term energy costs, while reducing the carbon footprint associated with the use of fossil fuels. In this context, the use of water pumping systems powered by photovoltaic panels has rapidly emerged as an effective solution, particularly in remote rural areas often lacking access to a conventional electricity grid.

The main objective of this study is to analyze the performance of a photovoltaic (PV) system dedicated to powering a three-phase asynchronous motor. This motor is used to drive a submersible pump, a key component in rural water supply systems. In addition, this system is combined with an energy storage device, ensuring a continuous supply of electricity even in the absence of direct sunlight, which is crucial for domestic services in environments where access to energy is intermittent.

The development of such technologies responds to a pressing need: to provide sustainable and economically viable solutions to water and energy needs in remote rural areas. In these areas, access to water is essential, not only for irrigating agricultural crops, but also for everyday domestic use. At the same time, often unpredictable weather conditions and limited access to traditional energy infrastructures make the use of autonomous systems such as photovoltaic installations essential.

This energy conversion system relies on a complex technological chain. Photovoltaic panels capture solar energy and transform it into electricity in the form of direct current. This electricity is then split between two routes: part is stored in a battery system, to compensate for variations in solar energy and ensure a continuous power supply, while another part is converted into alternating current via a three-phase inverter. This alternating current is required to drive a three-phase asynchronous motor, which in turn transforms electrical energy into rotating mechanical energy. This mechanical energy is used to drive a pump immersed in a borehole. The role of this pump is to draw large quantities of groundwater, an essential resource for hydraulic needs and agricultural irrigation.

The impact of this system goes far beyond the simple extraction of water. By reducing dependence on fossil fuels and centralized energy infrastructures, it makes a significant contribution to the development of rural areas. Using solar energy as the main source of power not only reduces long-term energy costs, but also improves the energy self-sufficiency of farms. In addition, the solar-powered pump enables farmers to secure their water supply, which is a key factor in the sustainable development of their activities, particularly in regions subject to arid or semi-arid climatic conditions.

The methodology adopted in this research is based on a robust mathematical model that simulates the operation of the system under different conditions. The model takes into account various parameters, such as solar radiation intensity, pump load fluctuations and battery state-of-charge. MATLAB/SIMULINK software was used to model and simulate these complex interactions, enabling system performance to be assessed in a variety of situations. This enables us to better understand the behavior of the photovoltaic system under real-life conditions, and to identify areas for improvement to maximize its efficiency.

The results of this simulation showed that the photovoltaic system studied is capable of supplying the energy needed not only to keep the submersible pump running smoothly, but also to power the essential electrical appliances in a small domestic dwelling. This is particularly important in areas where access to a stable power supply is limited. In addition, the integration of an energy storage system proved crucial in guaranteeing a stable electricity supply, reducing service interruptions due to variations in solar radiation, particularly during periods of low sunshine or at night.

In conclusion, this study demonstrates the effectiveness and viability of photovoltaic systems in agricultural and domestic applications in isolated rural areas. In addition to contributing to energy security and independence from fossil fuels, these technologies contribute to the sustainable development of rural areas by offering autonomous, reliable and environmentally-friendly solutions to water and energy needs.