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Solar Powered Water Pumping System with Induction Motor for Off-Grid Application: A Review

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Abstract: *The scarcity of reliable water pumping solutions in rural and off-grid communities presents an ongoing energy and agricultural challenge. Conventional diesel-powered pumps and grid-connected systems are associated with high operational costs, fuel price volatility, carbon emissions, and limited accessibility in remote regions. Solar photovoltaic (PV)-powered water pumping systems have emerged as a renewable solution, leveraging abundant solar resources to provide reliable irrigation and domestic water supply. Among motor choices available, induction motors (IM) are the most widely deployed in solar pumping due to their ruggedness, simple construction, low acquisition cost, and tolerance to environmental conditions. However, their efficiency is slightly lower compared to Permanent Magnet Synchronous Motors (PMSM) and Brushless DC (BLDC) motors. This paper reviews the state of research on solar-powered induction motor water pumping systems, providing detailed examination of PV module characteristics, power electronic converters, MPPT strategies, and motor drive control. The review also synthesizes findings from previous literature, identifies knowledge gaps, and provides a comparative discussion of methodologies used by different researchers. Through tabulated analysis, different solutions are compared based on economic, environmental, and technical criteria. Key challenges including solar intermittency, dust impacts, inverter reliability, and groundwater management are highlighted. Future prospects such as AI-driven MPPT, IoT-enabled condition monitoring, hybrid renewable integration, and innovative financing mechanisms are proposed. The review aims to serve as a resource for engineers, researchers, and policymakers in advancing the deployment of solar-powered water pumping for sustainable rural development.*

Keywords: Solar PV, induction motor, off-grid irrigation, MPPT, renewable water pumping, rural electrification

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