E-ISSN No : 2581-6195 | Volume : 9 | Special Issue | May 2026

GRID INTERACTIVE SOLAR PV BASED WATER PUMPING SYSTEM

Ummi Hani[1], S Rajesh[1], Raviteja B[1], M Sageer Ahmed[1], S MD Asif[1]

ABSTRACT

The integration of grid-interactive solar photovoltaic technology with water pumping systems provides a sustainable and efficient solution for agricultural irrigation and rural water management. The proposed system prioritizes solar energy for water pumping while interacting with the utility grid for backup and surplus energy export. The system uses solar PV panels, MPPT controllers, inverters, sensors, and BLDC motors for efficient operation. The use of BLDC motors improves efficiency, reliability, and operational lifespan compared to conventional motors. Intelligent controllers and monitoring systems ensure uninterrupted and optimized operation under varying environmental conditions. The proposed system reduces electricity consumption, minimizes dependence on diesel generators, and supports sustainable agricultural practices.

KEYWORDS: Solar PV, BLDC Motor, MPPT, Grid Interactive System, Water Pumping, Renewable Energy, Smart Irrigation

Access Online

Article DOI:
10.5281/zenodo.21413105

[1] Dept. of Electrical and Electronics Engineerning, Ballari Institute of Technology and Management, Ballari, Karnataka, India

How to Cite:
Ummi Hani, S Rajesh, Raviteja B, M Sageer Ahmed & S MD Asif (2026), Grid Interactive Solar Pv Based Water Pumping System, International Educational Journal of Science & Engineering (IEJSE),Vol: 9, Special Issue, May 2026 304-306

Research Paper

I. INTRODUCTION

Grid-interactive solar PV-based water pumping systems combine renewable energy generation with efficient water management. Traditional pumping systems depend on diesel generators or unreliable grid supply, resulting in high operational cost, pollution, and maintenance burden. Solar photovoltaic systems provide a clean and decentralized solution for irrigation applications.

The integration of BLDC motors increases energy efficiency and reduces maintenance requirements. Grid interaction allows the system to export excess solar energy and import power during low solar irradiance, ensuring uninterrupted operation. Such systems support sustainable agriculture and contribute toward renewable energyadoption.

In recent years, the increasing stress on conventional energy resources and the growing demand for agricultural productivity have intensified the need for innovative irrigation solutions. Solar-powered irrigation systems provide an environmentally friendly and economical alternative for rural communities. The system also supports smart agriculture by integrating monitoring and automation features.

II. LITERATURE SURVEY

Recent studies emphasize the importance of solar-powered irrigation systems. P. Srikanth et al. proposed IoT-based grid-connected irrigation systems with MPPT optimization and remote monitoring. A. Mehta and R. Patel demonstrated improved efficiency using BLDC motors and sensorless control algorithms.

N. Kumar et al. introduced hybrid solar-diesel pumping systems for reliability during low irradiance conditions. S. Sharma and D. Kumar focused on intelligent BLDC motor controllers with real-time speed control and MPPT techniques.

MNRE initiatives such as PM-KUSUM encourage the deployment of solar water pumping systems across India through subsidies and renewable energy programs. These studies confirm the feasibility and importance of grid-interactive solar pumping systems for future agricultural development.

III. METHODOLOGY

The proposed system includes a solar PV array, MPPT controller, grid-interactive inverter, BLDC motor, and utility grid interface. Solar energy is prioritized during daytime operation while the grid acts as backup during insufficient irradiance conditions.

The MPPT controller continuously extracts maximum power from the PV array. The inverter manages bidirectional power flow and controls the BLDC motor speed. Intelligent monitoring systems supervise voltage, current, motor speed, and water flow.

The methodology begins with solar assessment and load estimation. Based on the required water flow and head, the motor and pump ratings are selected. The PV array is sized considering average solar irradiance and system losses. The inverter automatically switches between solar mode and grid mode depending on power availability.

IV. BLOCK DIAGRAM AND WORKING PRINCIPLE

The block diagram represents the energy flow between the PV array, MPPT controller, inverter, grid interface, and BLDC motor pump. Solar power is converted into usable electrical energy for the motor pump through power electronic converters.

The system operates in two modes: solar mode and grid mode. During high solar availability, the motor is powered by solar energy. During low irradiance, the system automatically switches to grid supply while maintaining uninterrupted water pumping operation.

The BLDC motor provides smooth operation, high torque, low noise, and improved efficiency. The inverter performs synchronization with the utility grid and enables surplus energy export through net metering. Intelligent protection systems ensure safe operation under abnormal conditions.

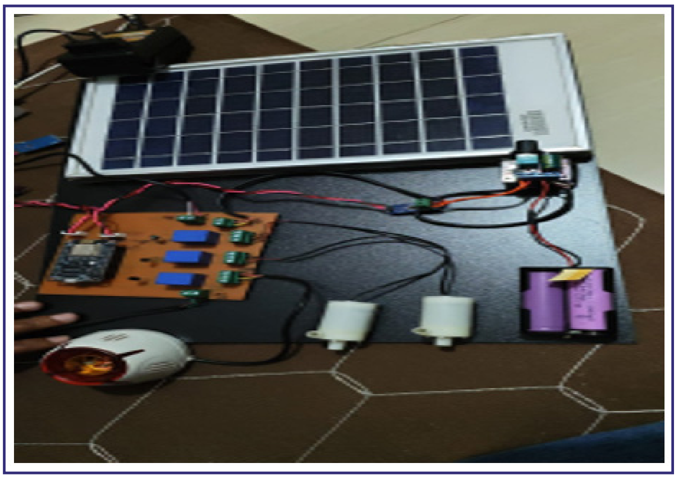
V. HARDWARE AND SOFTWARE COMPONENTS

Major hardware components include Solar PV Array, MPPT Charge Controller, Grid Interactive Inverter, BLDC Motor Pump, Grid Interface, and Protection Devices.

The solar PV array acts as the primary source of energy. The MPPT charge controller maximizes energy extraction from the solar panels under varying sunlight conditions. The grid-interactive inverter performs DC to AC conversion and enables bidirectional power flow.

Software components include MPPT algorithms, motor control logic, PWM generation, grid synchronization software, and monitoring systems. MATLAB/Simulink and embedded controller programming are used for simulation and control. Protection systems monitor voltage, current, temperature, and fault conditions.

VI. RESULTS AND DISCUSSION

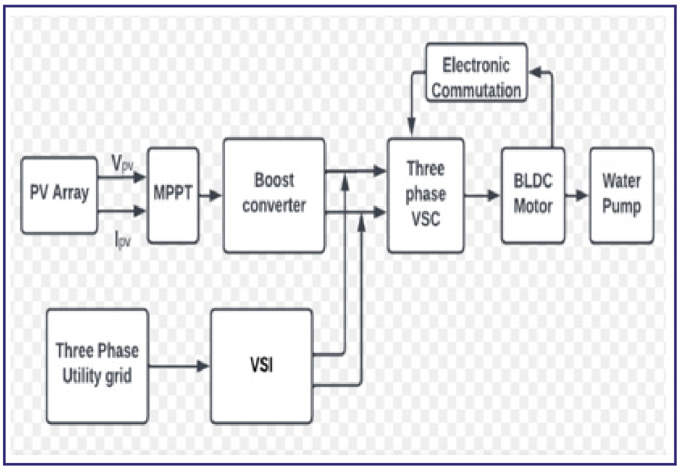


The system successfully operated in dual mode without interruption. MPPT control improved solar efficiency by approximately 20–25%. The BLDC motor maintained stable speed under varying irradiance conditions.

The system reduced grid electricity consumption and eliminated diesel usage. Net metering allowed surplus energy export to the utility grid, improving economic feasibility.

Protection mechanisms responded correctly during abnormal conditions such as overcurrent, undervoltage, and dry-run operation. The proposed system demonstrated high efficiency, reliability, and sustainability suitable for rural and semi-urban agricultural applications.

VII. ADVANTAGES AND APPLICATIONS



The proposed system provides high efficiency, low maintenance, uninterrupted operation, and reduced environmental impact. Grid interaction improves reliability and enables surplus energy export.

Applications include agricultural irrigation, greenhouse farming, rural water supply, livestock watering, aquaculture, and smart agriculture systems. The system is highly beneficial for remote and off-grid areas where conventional electricity infrastructure is unreliable.

The modular design allows future scalability by adding additional solar panels or higher-capacity pumps. The system also supports government renewable energy programs and sustainable rural development initiatives.

VIII. FUTURE SCOPE

Future developments include AI-based irrigation scheduling, IoT integration, cloud-based monitoring, advanced MPPT techniques, battery storage integration, and hybrid renewable systems.

Smart agriculture integration will improve water management and crop productivity. Government initiatives and renewable energy policies will further expand the adoption of solar PV-based water pumping systems across rural regions.

Future systems may include predictive maintenance, mobile-based monitoring applications, and hybrid renewable microgrid integration for enhanced performance and sustainability.

IX. CONCLUSION

The proposed grid-interactive solar PV-based water pumping system using a BLDC motor provides an efficient, sustainable, and economical solution for agricultural applications. The integration of solar energy with grid interaction ensures reliable operation and optimized energy utilization.

The system contributes toward renewable energy adoption, smart irrigation, and sustainable rural development while reducing environmental impact. Intelligent monitoring, automation, and energy management improve system reliability and long-term performance.

The project confirms the technical and economic feasibility of grid-interactive solar pumping systems and highlights their importance in modern sustainable agriculture.

REFERENCES

1. P. Srikanth et al., “Grid-connected solar irrigation system with IoT control,” 2024.
2. A. Mehta and R. Patel, “Standalone solar-powered water pump using BLDC motor,” 2023.
3. N. Kumar et al., “Hybrid solar-diesel-powered water pumping system,” 2022.
4. S. Sharma and D. Kumar, “Smart BLDC motor controller for solar water pumps,” 2021.
5. MNRE Reports – Government of India, PM-KUSUM Scheme.
6. R. Kumar and B. Singh, “BLDC Motor Driven Solar PV Array Fed Water Pumping System,” IEEE Transactions.
7. Bhim Singh and Rajan Kumar, “Solar PV Array Fed Water Pumping Driven by BLDC Motor,” IET Renewable Power Generation.