Solar and Grid Power Hybrid Water pumping system Employing DC and AC dual Pump

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Abstract - To reduce the grid power consumption a hybrid solar and grid power energy system is proposes in this paper. A system is developed to utilize solar energy available in all climatic condition which is unlikely in a solar powered water pumps directly operating on solar panels .our system is for utilizing maximum use of solar energy and to minimize the consumption of grid power . This system takes the DC current created from the solar panels and converts it to AC current to operate the pump and is not reliant on any power grid. Water can then be pumped wherever there is sun. It is very light weight, cheap, easy to carry, assemble and operate.

Keywords— Solar power, DC to AC Conversion* , Off-grid pumping , *Automatic water pump* , *Switching circuit* , *AC grid power supply* , *Power supply

I Introduction

The Solar and Grid Power Hybrid Water Pumping System cleverly combines the dependability of grid power with the efficiency of solar energy, marking a substantial advancement in water management technology. This hybrid system switches between grid and solar power intelligently in response to demand and availability in real time, ensuring constant and efficient water pumping. This seamless integration mitigates the restrictions associated with each power source independently, delivering a robust and trustworthy solution for numerous applications like agriculture, industrial water supply, and domestic water management.

This system's main novelty is its advanced control mechanism, which modifies pump operations to maximize water use. The system maximizes energy efficiency and saves operating expenses by using solar energy throughout the day and switching to grid power when solar energy is not adequate. In addition to ensuring a steady supply of water, this dynamic power management lessens reliance on non-renewable energy sources, which lowers carbon emissions and promotes environmental sustainability.

Furthermore, the incorporation of sophisticated technologies such as smart sensors and Internet of Things (IoT) boosts the system's functionality and adaptability. With the use of these technologies, automatic control and real-time monitoring are made possible, enabling accurate modifications based on water levels, weather, and power availability. This degree of control makes sure the system always runs as efficiently as possible and helps avoid wasting water.

By tackling the pressing problems of water shortage and energy sustainability, the Solar and Grid Power Hybrid Water Pumping System not only offers technological benefits but also contributes to the achievement of global sustainable development goals. The system is a useful tool in initiatives to support sustainable agriculture and enhance water access in isolated or underserved areas because of its capacity to deliver a steady water supply utilizing renewable energy sources.

II Literature Review

In the paper "Performance Enhancement of Grid-Off Photovoltaic Pumping System-Quasi Z Source Inverter by Hybrid Battery-Supercapacitor Energy Storage" presented by Seif eddine Boukebbous , Djallel Kerdoun et.al[1] propose an off-grid solar photovoltaic water pumping system utilizing a quasi z-source inverter combined with a hybrid battery-supercapacitor energy storage. This approach aims to improve system reliability under varying meteorological and water conditions by leveraging the high energy density of batteries and the high power density and long cycle life of supercapacitors. The analysis through Matlab simulations demonstrates enhanced power flow performance and system robustness.

In "Solar, Wind, and Hybrid Wind-PV Water Pumping Systems—An Electrical Engineering Perspective" by Sachin Angadi, Udaykumar R. Yaragatti, the authors review the advancements in renewable energy-based water pumping systems (REWPS) in India. With increasing water demand and reliance on fossil fuels, the paper highlights the transition to solar and wind-powered AC motor water pumping systems to reduce greenhouse gas emissions and pump life cycle costs. The review covers single-stage and multi-stage systems, emphasizing motor types, power electronics interfaces, control strategies, and hybrid Wind-PV systems to enhance efficiency and reliability

In "Photovoltaic and Wind Energy Hybrid Sourced Voltage Based Indirect Vector Controlled Drive for Water Pumping System" by Amritesh Kumar, Eira Kochharthe et.al[3] explores the integration of solar and wind energy for rural water pumping applications. The system utilizes a common DC bus for energy integration, driving a vector-controlled induction motor connected to a water pump. A bidirectional DC-DC converter and small battery maintain required voltage during transients. Simulated in MATLAB-Simulink, the study presents performance results under varying solar insolation and wind speeds.

An Efficient and Credible Grid-Interfaced Solar PV Water Pumping System with Energy Storage by Anjanee K. Mishra introduces a grid-interfaced solar photovoltaic (PV) water pumping system designed to improve energy efficiency and power quality. The system integrates energy storage through batteries and operates using a switched reluctance motor. An MNF-based control technique, combined with an H-bridge converter, enhances the power management of the system. This control structure addresses common issues in water pumping applications, such as voltage fluctuations, by improving system stability. The use of renewable energy sources like PV for water pumping showcases an innovative solution to sustainable energy usage in agricultural applications. However, the system faces challenges primarily related to the complexity introduced by the switched reluctance motor drive. These motors, while efficient, often require higher maintenance, making the overall system less appealing for widespread adoption in areas where technical expertise might be limited. Additionally, tuning the modified notch filter, crucial for the system's performance, demands careful calibration, which can introduce difficulties in real-world scenarios. Thus, while the solution offers considerable benefits in terms of energy savings and sustainability, its implementation may involve high operational overhead.

The paper titled "A Hybrid PV Battery Supported Water Pumping System with Enhanced Boost Converter" by Indrojeet Chakraborty, Sreejith S and Sovit Kumar Pradhan (2023) presents a novel approach to water pumping using a hybrid system that combines photovoltaic (PV) energy with battery storage. The system employs a boosted converter to enhance the PV array voltage and is coupled with a brushless DC (BLDC) motor to improve efficiency. This hybrid configuration allows the system to operate effectively in off-grid areas, utilizing both PV energy and stored battery power to ensure uninterrupted water pumping, even in fluctuating environmental conditions. The use of advanced power converters helps manage voltage drops and ensures reliable performance, making this system particularly beneficial for applications in rural areas without stable access to the electrical grid.

However, the system also presents several challenges. The reliance on advanced electronics, such as boosted converters and BLDC motors, increases the complexity of the system, which could pose difficulties in terms of maintenance and repairs, especially in remote areas with limited technical expertise. Additionally, the system’s performance is highly dependent on weather conditions, particularly solar irradiance. Prolonged periods of low sunlight may reduce the system's reliability, necessitating the use of additional backup mechanisms or larger battery storage, which in turn could increase both the initial cost and the ongoing maintenance burden of the system. Thus, while the hybrid water pumping system offers significant benefits for off-grid applications, these advantages are tempered by its complexity and sensitivity to environmental factors.

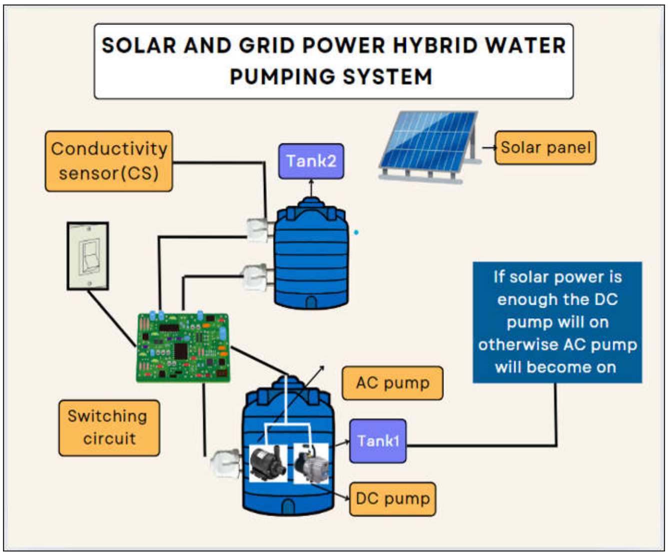
Intelligent Grid Interfaced Solar Water Pumping System by Tamboli Kadar Shahajahan, Shailendra K. Mittal, in 2020 presented a solar-based water pumping system that integrates an Induction Motor Drive (IMD) with a smart power-sharing strategy. The proposed system eliminates the need for DC-DC conversion, simplifying the design. By leveraging grid-connected solar energy, the system aims to provide an efficient water pumping solution for agricultural and rural areas. The induction motor ensures reliable operation, and the system's design supports seamless transition between grid power and solar energy to ensure consistent water supply.

However, the system faces drawbacks such as limited efficiency due to its single-stage conversion approach, which may not be optimal for all operational scenarios. Additionally, implementing the power-sharing strategy introduces complexity, particularly in managing the motor drive under varying environmental conditions. The reliance on induction motor drives, especially in harsh operating environments, may lead to performance degradation or increased maintenance requirements. These challenges highlight the need for further optimization in system design and control strategies to ensure long-term reliability and ease of operation.

Grid Supported Solar Water Pump System by Atul Lilhare, S.G. Kadwane, in 2021 discusses a water pumping system that combines a photovoltaic (PV) array, boost converters, an induction motor, a centrifugal pump, and a VSI inverter. The system utilizes the Perturb and Observe method for maximum power point tracking (MPPT) to optimize the use of solar energy, ensuring efficient energy conversion. A proportional-integral (PI) controller maintains the DC link voltage, providing stability to the system and regulating the motor's speed to enhance its overall performance. This design makes the system suitable for grid-supported operations where solar energy is supplemented by grid power.

Despite its strengths, the system encounters challenges related to voltage and frequency control, which can impact motor speed regulation. Addressing power quality issues becomes critical to ensure system stability, especially during periods of fluctuating solar input or grid power inconsistencies. While the design addresses these issues to some extent, further improvements in control algorithms and system integration are required to optimize its efficiency and long-term operation in real-world applications.

III METHODOLOGY



This Solar and Grid Power Hybrid Water Pumping System presents a combination of DC and AC water pumps, in order to provide an efficient way for water pumping. It consists of a solar panel, AC grid power supply, reverse current blocking diode, battery charger input relay, super capacitor or the battery bank with protection; water level controller; DC pump motor On/Off relay; AC pump motor On/Off relay; pumping system controller and nonreturn valves (NRV). This system features a combination of both DC and AC pumps, where as existing systems only utilize one.

DC and AC pumps operate using two different source of energy — SPV panel (Solar photovoltaic panel) for DC and AC mains supply. The reverse current blocking diode bypass the SPV panel output towards the super capacitor bank. The SPV panel size and DC pump can be optimized for the pumping requirements. On the other side, the AC grid supply arrives at the AC motor pump that is activated by an On/Off relay and controlled by a system controller.

The pump system runs only when the potable water level controller turns it on by sending signals to the system controller. In this rackthe solar energy from the spv panel which is lost without any work in DC pump idle condition during that time we can connect other batteries as load ie to charge these by making battery charger input relay ON and off based on requirement interlocking with the dc load.

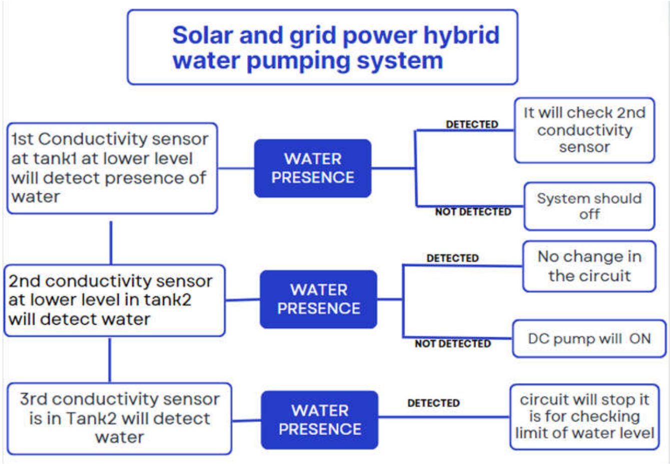
If the solar power is low or not at all (as sensed by the voltage of super capacitor bank) then that state relay will be on and system controller will close the AC pump through its relay. The energy is stored in a super capacitor bank from the SPV panel which sends sufficient power to the DC pump, enabling it to work even under low irradiation conditions.

DC and AC pump outlets are made to a T-type coupling that is used as a common outlet. NRV valves are fitted to eliminate the possibility for backpressure preventing further delays in this system operation.

In this combined system where pumping is continuous, solar and grid power can be fully utilized however stored energy and the most available energy source, water pumping can also being done in the most optimum way.

IV RESULT AND DISCUSSION

The design of the solar and grid power hybrid water pumping system architecture proposed in this paper attempts to maintain the water levels in two tanks in a manner that saves power. Three conductivity sensors are fitted at designated positions inside the tanks for water outflow prevention and water levels monitoring.



Tank 1 comprises the first conductivity sensor installed at the lower level of the tank. It detects the water level in the tank. When the water level is measured, the system proceeds to check the second conductivity sensor. Within a relation, if no water is measured, the system will be turned off to save power.

The second conductivity sensor is also located on the lower level of Tank 2. Its purpose is to determine whether there is water in Tank 2. If water is detected, the system will continue to function without making any adjustments to the circuit. If no water is found, the DC pump will be triggered, transferring water from Tank 1 to Tank 2.

The third conductivity sensor is installed in Tank 2 to monitor the water level. Its goal is to keep the water level from exceeding a predetermined limit. If the sensor detects that the water level has reached its maximum capacity, the circuit will immediately turn off the system to prevent overflow. In result, this system architecture efficiently uses conductivity sensors to monitor water levels in both tanks. The DC pump and the complete system are automatically activated and deactivated depending on sensor readings, ensuring effective water management and energy conservation.

V CONCLUSIONS

The Solar and Grid Power Hybrid Water Pumping System Employing DC and AC Dual Pump stands as a transformative solution for sustainable water management, combining the strengths of renewable solar energy with the reliability of grid power. This innovative system not only ensures uninterrupted operation through its dual energy sources but also introduces a dual-pump configuration—utilizing both DC and AC pumps—to optimize efficiency and adaptability in varying environmental and operational conditions. The hybrid design reduces electricity consumption, operational costs, and carbon emissions, making it an ideal choice for environmentally conscious applications.

The system's ability to function seamlessly during grid power failures, coupled with advanced pump control strategies, ensures a continuous and stable water supply in critical scenarios. By addressing the challenges of energy reliability and water scarcity, this hybrid system offers a forward-thinking approach to water pumping in both rural and urban settings. Its integration of solar energy and grid power provides a resilient, cost-effective, and eco-friendly solution, paving the way for future innovations in sustainable water resource management.

VI FUTURE SCOPE

- Integration of AI and Machine Learning:

Predict water demand and optimize power source switching with AI and machine learning.

- Superior Energy Storage Technology:

Research on next-generation batteries and supercapacitors to boost energy storage efficiency and capacity.

- IoT with Smart Sensors:

To increase system responsiveness, use IoT-enabled sensors for automated control and real-time monitoring.

- Hybrid Renewable Systems:

Incorporate extra renewable energy sources, such as wind power, to lessen your reliance on the grid.

- Adaptable and Modular Architecture:

Create modular designs that are easily customizable and scalable to meet the needs of a wide range of users and applications.

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