Current Journal of Engineering and Science Research
Volume 2, Issue 3, pp 19-22, March 2025
ISSN (online): 3049-1738
DOI: https://doi.org/10.47001/CJESR/2025.203004
Available Online at https://www.cjesr.com

Solar and Wind Powered Automatic Water Pumping System

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Abstract: Water scarcity and inefficient irrigation practices have driven the need for automated and renewable energy-based water pumping systems. This paper presents a solar and wind-powered automatic water pumping system that uses renewable energy sources to pump water efficiently. A solar panel and wind generator charge a 12V lead-acid battery, with a DC-DC converter acting as a charge controller to regulate power. The system incorporates Arduino Uno and a soil moisture sensor, which detects soil moisture levels and automatically turns the pump on or off as needed. The Arduino controls the motor through a relay, ensuring an efficient and smart irrigation solution. This setup not only reduces dependency on non-renewable energy but also optimizes water usage in agriculture. The proposed system is a cost-effective, sustainable, and eco-friendly solution for water pumping, particularly in rural and off-grid areas.

Keywords: Solar power, Wind, Automation, Water pumping system, Energy based system, Hybrid power, Embedded system, Arduino based research, Irrigation system.

I. INTRODUCTION

Agriculture is the backbone of many economies, and efficient irrigation is essential for maximizing crop yield. Conventional water pumping systems rely on grid electricity or diesel-powered pumps, both of which pose challenges such as high operational costs, environmental pollution, and dependency on unreliable power sources.

Renewable energy sources such as solar and wind power provide an excellent alternative to conventional energy sources. Solar-powered water pumps have been widely used, but their efficiency is limited by weather conditions. By integrating a wind generator with a solar panel, a more reliable and continuous power supply can be achieved.

This project provides a detailed overview of the hardware components, their working principles, and the advantages and applications of the system.

II. OBJECTIVES

The primary objectives of this project are:

1. To develop an automatic water pumping system that runs on solar and wind energy.

2. To integrate a soil moisture sensor for real-time monitoring and control of irrigation.

3. To reduce dependency on grid electricity and fossil fuels by using renewable energy sources.

4. To ensure water conservation by irrigating only when necessary.

5. To design a cost-effective and low-maintenance solution for rural and off-grid areas.

III. LITERATURE SURVEY

Several studies have explored the integration of renewable energy sources into irrigation systems.

1. Solar-Powered Irrigation Systems

Sharma & Patel (2022) discussed the benefits of solar-based water pumps in agricultural irrigation, highlighting their cost savings and efficiency.

Limitations: Sole reliance on sunlight affects efficiency in cloudy weather.

2. Wind-Solar Hybrid Power Systems

Kumar & Singh (2021) explored hybrid solar-wind energy systems, showing that combining wind and solar energy enhances power availability and system reliability.

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3. Automated Irrigation Using IoT

Khan & Gupta (2020) studied the use of microcontrollers and IoT sensors for irrigation automation. Their findings suggest that automated soil moisture-based systems improve crop yield while reducing water wastage.

4. Renewable Energy Storage

Recent research emphasizes the role of batteries and charge controllers in ensuring uninterrupted power supply for water pumps, even during low sunlight or wind conditions.

IV. PROPOSED SYSTEM

The proposed solar and wind-powered automatic water pumping system is designed to provide a renewable energy-based, automated irrigation solution. The automatic water pumping system proposed in this project is designed to work efficiently using solar and wind energy. A 12V lead-acid battery is used to store energy, ensuring uninterrupted operation. The Arduino Uno microcontroller and a soil moisture sensor enable automatic pump control, turning the pump on or off based on soil moisture levels. This system eliminates manual intervention, ensuring optimal irrigation and water conservation. The proposed system is cost-effective, eco-friendly, and ideal for agricultural applications, particularly in off-grid rural areas where electricity supply is unreliable.

Block Diagram

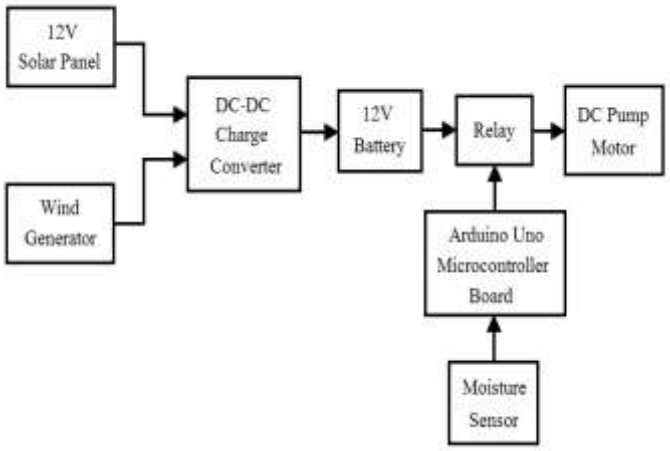

Figure 1: Block diagram of proposed system

Description

The system consists of a solar panel and a wind generator that work together to generate electricity, which is regulated by a DC-DC charge controller and stored in a 12V lead-acid battery. The Arduino Uno microcontroller is the central control unit, which receives real-time data from a soil moisture sensor placed in the field. Based on the moisture levels detected, the Arduino activates or deactivates a relay module, which in turn controls a DC water pump for irrigation. This ensures that water is supplied only when needed, reducing wastage and improving efficiency. The integration of battery storage allows the system to operate even during low sunlight or wind conditions, ensuring continuous and reliable irrigation.

The major hardware components of the system include:

- Power Generation Components
- Solar Panel: Converts sunlight into DC electricity.
- Wind Generator: Generates DC power from wind energy.

DC-DC Converter (Charge Controller): Regulates the charging of the battery.

1. Solar Panel

A solar panel converts sunlight into DC electricity, which is used to charge the 12V lead-acid battery. The capacity of the panel is chosen based on power requirements.

2. Wind Generator

A small wind turbine is used to generate additional electricity to complement the solar panel. This ensures power availability even during low sunlight conditions.

3. 12V Lead-Acid Battery

The battery stores energy generated from the solar panel and wind generator and supplies power to the system when required.

4. DC-DC Converter (Charge Controller)

The charge controller manages the power flow from the solar panel and wind generator to the battery, preventing overcharging and ensuring efficient charging.

5. Arduino Uno

The Arduino Uno microcontroller is the brain of the

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system. It receives input from the soil moisture sensor and controls the water pump motor through a relay.

6. Soil Moisture Sensor

This sensor detects the moisture level in the soil and sends data to the Arduino. Based on predefined moisture thresholds, the Arduino decides whether to turn the pump on or off.

7. Relay Module

The relay acts as a switch that allows the Arduino to control the pump motor based on moisture sensor data.

8. Water Pump Motor

A DC water pump is used to pump water from the source to the irrigation system. The relay controls its operation.

Working of Hardware

1. Power Generation: The solar panel and wind generator produce DC electricity, which is regulated by the charge controller and stored in the 12V lead-acid battery.

2. Moisture Sensing & Data Processing: The soil moisture sensor continuously measures soil moisture and sends readings to the Arduino Uno.

3. Pump Control: If the soil is dry (moisture level below threshold), the Arduino activates the relay, turning on the water pump. If the soil is sufficiently wet (moisture level above threshold), the Arduino deactivates the relay, turning off the water pump.

4. Efficient Water Usage: The system ensures water is pumped only when needed, preventing over-irrigation and water wastage.

5. Storage and Power Management: 12V Lead-Acid Battery (20Ah): Stores energy to run the pump during low sunlight/wind periods.

6. Control and Sensing Units:

Arduino Uno: Processes sensor data and controls the pump.

Soil Moisture Sensor: Measures soil moisture and sends data to the Arduino.

Relay Module: Acts as a switch to turn the pump on or off.

7. Water Pumping System: DC Water Pump (12V): Pumps water to the irrigation system. Distributes water to the field.

Applications

- Agricultural Irrigation: Ensures optimal watering for crops.
- Greenhouse Farming: Automates moisture control for greenhouse plants.
- Remote Villages & Off-Grid Areas: Provides water pumping solutions where electricity is scarce.
- Livestock Farming: Ensures continuous water supply for animals.

Applications

The proposed system can be widely used in various fields, including:

- Agriculture: Ideal for farms and plantations requiring automated irrigation.
- Gardens and Greenhouses: Useful for maintaining optimal soil moisture in gardens and greenhouse environments.
- Remote and Off-Grid Areas: Provides a sustainable water pumping solution in areas with limited or no access to electricity.
- Livestock Farming: Ensures a continuous water supply for livestock drinking needs.

Advantages

- Reduces dependence on electricity and fossil fuels.
- Automated Operation no manual intervention is needed.
- Optimizes water usage by irrigating only when required.
- Uninterrupted Operation by battery ensures continuous operation.
- Low Maintenance, Cost-Effective and no electricity bills.
- Eco-Friendly and Reduces carbon emissions and supports sustainability.

V. CONCLUSION

The proposed solar and wind-powered automatic water pumping system is expected to provide a sustainable, energy-efficient, and automated irrigation solution for agriculture and other water supply applications. By utilizing solar and wind energy, the system will significantly reduce dependence on conventional electricity, lowering operational costs and promoting eco-friendly farming practices. The Arduino-controlled automation will ensure optimal water usage, preventing over-irrigation and conserving water resources. The

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battery storage will enable uninterrupted operation, even during low sunlight or wind conditions. This system is expected to enhance agricultural productivity, particularly in remote and off-grid areas, by providing a reliable, low-maintenance, and cost-effective irrigation solution.

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Citation of this Article:

Malarvizhi S, Nisshanthee N, & Prabakar MN. (2025). Solar and Wind Powered Automatic Water Pumping System. *Current Journal of Engineering and Science Research*. 2(3), 19-22. Article DOI: https://doi.org/10.47001/CJESR/2025.203004

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