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AN ECONOMICAL BATTERY- COUPLED SOLAR WATER PUMP USING HIGROW SENSOR MODULE

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ABSTRACT
Water scarcity and rising energy costs represents a significantchallenge to modern agriculture. This project presents an innovative, cost-effective, and eco-friendly solution designed to address the challenges of water scarcity and increasing energy expenses. An economical battery-coupled solar water pump using HiGrow sensor module provides a water pumping system that uses solar energy to pump water from a water source and detects the atmospheric temperature, soil moisture and humidity. This system consists of solar panel, solar charge controller, Buck Converter, DC motor, relay module, water pump, battery and HiGrow sensor module. This system utilizes solar energy to power the water pump coupled with a battery storage system to ensure continuous operation even during periods of low sunlight. The HiGrow sensor module enables continuous monitoring and collection of environmental data by incorporating temperature, humidity, and soil moisture sensors. These sensors work in tandem with an ESP32 microcontroller to gather real-time data, which is then transmitted and displayed on the ThingSpeak website by using Arduino IDE softwareand C++ Programming language. Based on the real-time data received from the HiGrow sensor, the motor is automatically operated to ensure optimal irrigation practices and ultimately advancing a sustainable agriculture through the integration of renewable energy and smart sensor technologies.
Keywords: Solar power, HiGrow sensor module, Battery storage system, Microcontroller.

INTRODUCTION
An economical battery-coupled solar water pump using HiGrow sensor module is a system designed to address the challenges faced by farmers in India, where agriculture is still the primary source of income, and power supply and demand gaps exist. This system aims to automate irrigation, reduce manual labor, and utilize renewable energy sources, thereby promoting sustainable farming practices and reducing air pollution caused by fossil fuels.The HiGrow sensor module is used to monitor soil moisture, temperature, and other environmental factors, enabling the system to optimize water usage and conserve energy. The solar water pump is powered by renewable solar energy, and the battery ensures continuous operation during periods of low sunlight or at night. This setup reduces the reliance on fossil fuels and minimizes environmental impact while providing a reliable and cost-effective solution for farmers.Byadopting this technology, farmers can benefit from water conservation, energy efficiency, reduced labor costs, increased crop yield, and reduced greenhouse gas emissions. The government can promote the adoption of this technology by providing incentives, creating awareness, and establishing a supportive policy framework. It is the most eco-friendly and user-friendly system as the soil conditions can be monitored by this sensor which further can also be viewed in the smart phone of the user by ThingSpeak. This process is introduced for knowing the accurate

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conditions of the soil as it helps with the cultivation of crops.

LITERATURESURVEY

S. Bipasha Biswas et.al.,[1] designed and demonstrated an automated solar water pumping system for irrigation in Bangladesh. This system uses a water storage tank as a source and a ESP32 Microcontroller for cost-effectiveness and remote operation. The system meets the irrigation needs of developing countries by combining sensors, internet communication, and user-friendly controls.

Shahidul I Khan et.al.,[2] developed and tested a low-cost solar water pump for irrigation in Bangladesh. This system employs an automated solar water pumping system that includes a low-cost 1 hp (746 W) DC photovoltaic pump for irrigation. A buck converter is designed to enhance pump performance. This system uses no batteries or inverters, making it cost-effective and low-maintenance, addressing energy crises during the irrigation season in Bangladesh.

Prakhar Kumar Singh et.al., [3] developed a Microcontroller based water pumping system by using stand alone solar energy. This system, which uses solar photovoltaic (PV) energy as its primary source, provides a cost-effective watering option. The inclusion of a battery in the design enhances its economic viability. This study significantly contributes to the field of solar-powered water pumping systems by achieving cost efficiency and addressing the needs of field irrigation.

A. Agrawal et.al., [4] designed and demonstrated a cost-effective and solar-based automatic irrigation system using a microcontroller This system employs soil moisture sensors that trigger the motor to turn the irrigating pump on or off, thereby optimizing water utilization for farmers. By harnessing solar energy and integrating moisture sensing technology, this innovative system effectively addresses water scarcity challenges in agriculture. This design not only offers a sustainable solution for agricultural practices but also promotes efficient water usage, contributing significantly to the field of smart irrigation systems.

J. Gutiérrez et.al., [5] have designed an innovative Automated Irrigation System using a Wireless Sensor Network and GPRS Module. This system features a distributed wireless network of soil-moisture and temperature sensors, which are strategically placed in the root zone of plants. A microcontroller-based gateway controls water quantity based on threshold values, resulting in up to 90% water savings compared to traditional irrigation practices.

H. Meena et.al., [6] have designed an IoT-based perceptive monitoring and controlling system for an automated irrigation system. Their innovative approach features an Arduino-based smart irrigation system that efficiently monitors and controls water resources. The system sends motor ON/OFF commands through microcontroller-driven updates, keeping users informed about the field status.

By leveraging IoT technology, this system optimizes water usage, making it a valuable contribution to sustainable agriculture and water management.

P. Jain et.al., [7] created and presented an irrigation management system using a microcontroller application. The paper presents an optimal irrigation strategy for crop-specific irrigation operations that makes use of automatic water control. This device uses microcontroller technology to improve modern agriculture techniques and ensure effective water consumption.

EXISTINGSYSTEM

A smart solar water pumping system with bidirectional power flow typically consists of a solar photovoltaic (PV) array, a water pump, a power converter, and a control system. The solar PV array converts sunlight into electrical energy, which is then used to power the water pump. The power converter is used to convert the DC power generated by the solar PV array into AC power required by the water pump. The control system manages the power flow between the solar PV array, the power converter, and the water pump. In a bidirectional power flow system, the power can flow in both directions. This means that when the solar PV array generates more power than what is required by the water pump, the excess power can be fed back into the grid. Conversely, when the solar PV array is not generating enough power (such as during cloudy weather or at night), power can be drawn from the grid to meet the water pump's requirements. The control system plays a crucial role in managing the power flow and ensuring the efficient operation of the system. It uses various sensors and algorithms to monitor the power generated by the solar PV array, the power consumed by the water pump, and the power available from the grid. Based on this information, it adjusts the power converter's operation to ensure that the water pump receives the required power while minimizing energy wastage. Some advanced smart solar water pumping systems also incorporate energy storage devices such as batteries. These devices can store excess power generated by the solar PV array and supply it to the water pump when the solar PV array is not generating enough power. This further enhances the system's efficiency and reliability. Overall, a smart solar water pumping system with bidirectional power flow offers a sustainable and efficient solution for water pumping applications. It can help reduce energy costs, minimize greenhouse gas emissions, and ensure a reliable water supply even in remote and off-grid location.

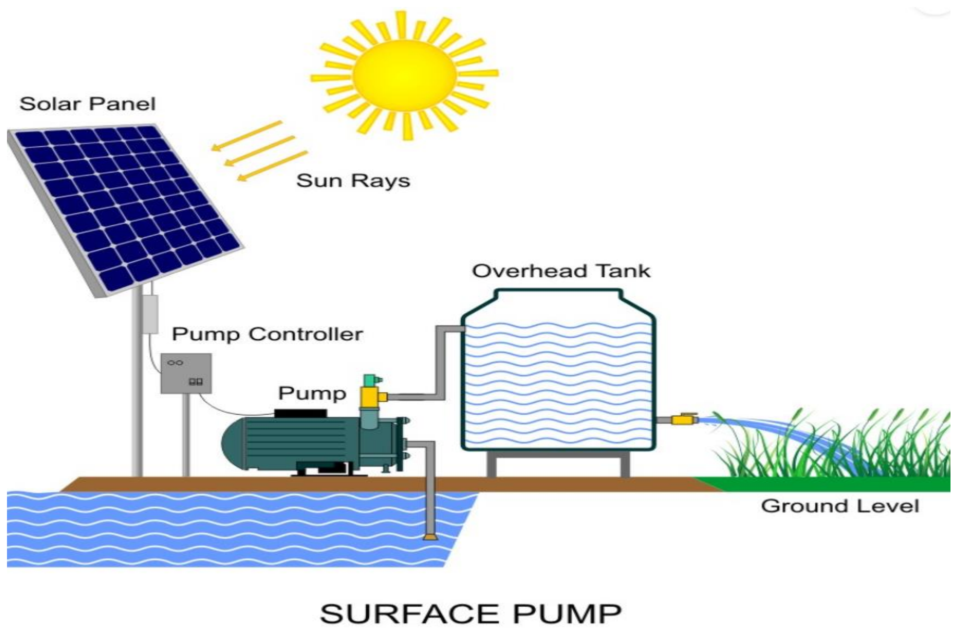


Fig-1: Solar powered surface water pump

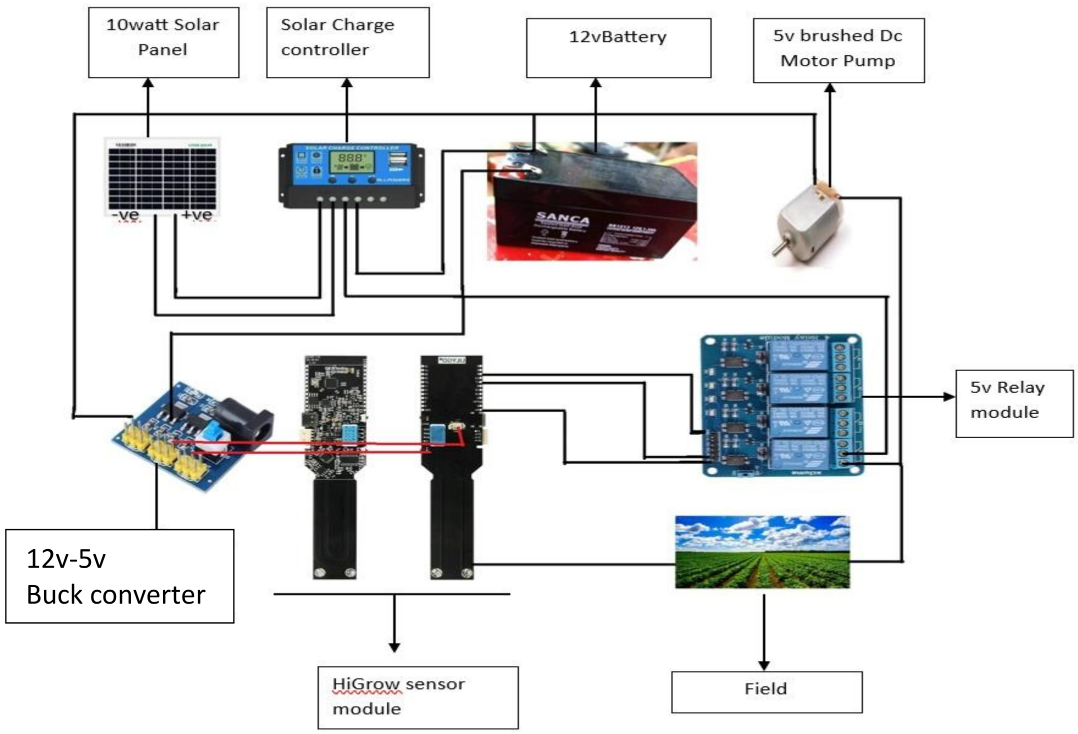


Fig-2:Electrical block diagram for proposed model

PROPOSED METHOD

The proposed control system is based on the ESP32 microcontroller device and battery storage which helps to store the excess energy generated during sunny hours and provide power during cloudy days or at night when solar panels are inactive. The solar energy behaves as a primary energy source, whereas battery is used as a backup source. We present a detailed control system of an automatic solar water pumping system for irrigation. A simple and quite low-cost modern ESP32 controlled irrigation system is presented here which is affordable for farmers in developing countries. The proposed system can improve the traditional irrigation system by lowering its cost and has features compatible with current technology.A microcontrollercan receive the data collected from the HiGrow sensor module, which can be used to track the moisture content of the soil. The microcontroller has the ability to turn on the solar water pump to irrigate the field based on the moisture content. A battery that can be charged by solar panels may power the solar water pump. For plant monitoring, the HiGrow sensor module serves as a comprehensive development board.ADHT11 sensor that measures humidity and temperature is also present on the board. The temperature and moisture content of the soil can be tracked with these sensors. The moisture levels can be used to command the microcontroller to turn on the solar water pump. For example, the microcontroller can turn on the pump to water the field if the moisture content drops below a predetermined level. Additionally, the microcontroller can keep an eye on the battery's levels to make sure it isn't overcharged or overdischarged. A DC motor and a water pump can be used to build the solar water pump. Water can be pumped from a source to the field using the water pump, which is driven by the battery in the DC motor. Throughout the day, the battery can be charged using the solar panels. The HiGrow sensor module, ThingSpeak, and Arduino IDE software are integrated into a suggested battery-coupled solar water pump system that provides a creative way to manage water effectively in residential or agricultural contexts. In order to provide a steady source of power, the system would use solar panels to capture renewable energy and charge a battery. The HiGrow sensor module would keep an eye on important environmental factors including temperature, humidity, and soil moisture content to guarantee ideal circumstances for plant development and economical water use. The sensor data would be gathered, examined, and sent to the ThingSpeak platform for real-time tracking and analysis using the Arduino IDE software. This integration improves the overall efficacy and dependability of the system by enabling users to remotely monitor the water pump's operation, change settings as necessary, and receive warnings for any abnormalities. Finally, the suggested approach seeks to maximize water conservation efforts while encouraging sustainable agricultural practices.

THE DESIGN STRUCTURE

An Economical battery-coupled solar water pump using HiGrow sensor module is a system that utilizes solar energy to power a water pump and detect environmental data. The system consists of a solar panel, solar charge controller, Buck Converter, DC motor, relay module, water pump, battery, and HiGrow sensor module. The HiGrow sensor module acts as a brain of the system. This sensor controls the circuit function and various components are interfaced with this sensor to perform desired operation of the system. solar panels harvest sunlight and transform it into electrical energy, while the solar charge controller manages battery charging by linking them to the panels.Rechargeable batteries store solar energy generated during the day, serves as a power source for the entire system, including the microcontroller and water pump and enable operation even during low sunlight or at night. The Buck Converter steps down the voltage from the battery to a level suitable for the HiGrow sensor.HiGrow sensor module is placed in the soil of the plant pot to monitor the parameters such as soil moisture, temperature, and humidity. The sensor module communicates with the microcontroller to provide data on the plant condition. The system utilizes a relay module controlled by the microcontroller, which activates based on sensor readings to turn the water pump ON or OFF as needed and effectively ensuring water is supplied
to the plants only when it is necessary, thereby optimizing water usage and conserving energy.

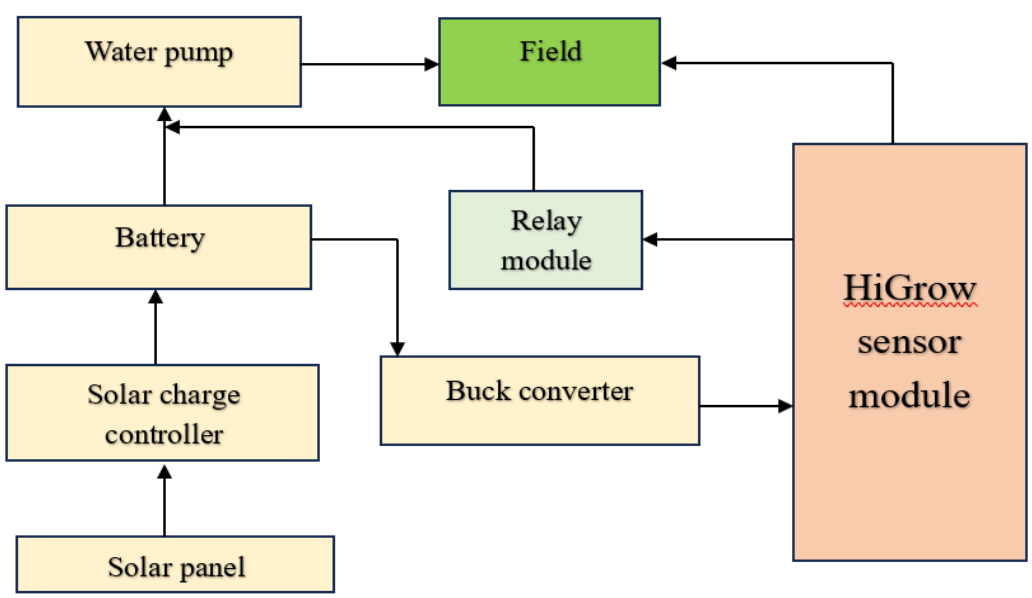


Fig-3: Block Diagram of a battery-coupled solar water pump using HiGrow sensor module

RESULTANALYSIS

Fig-4: Experimental setup

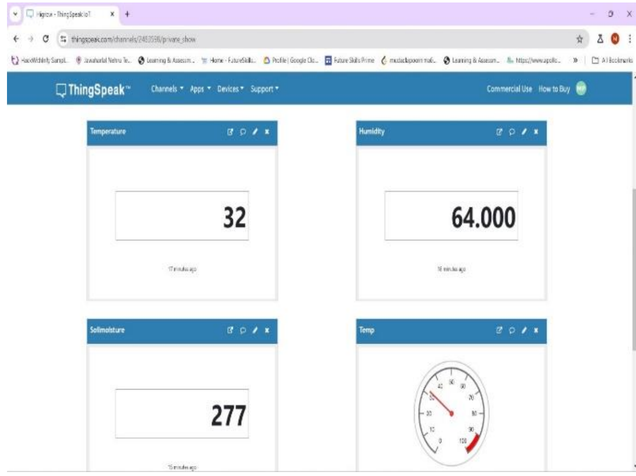


Fig-5: ThingSpeak Output

Parameters	Dry soil	Wet soil
Soil Moisture	350	117
Temperature	38	37
Humidity	37	35

Table-1: Soil moisture, Humidity and Temperature using HiGrow sensor

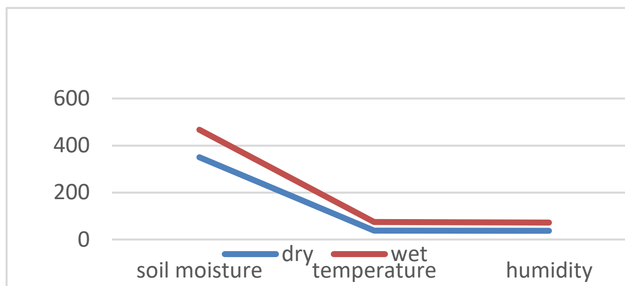
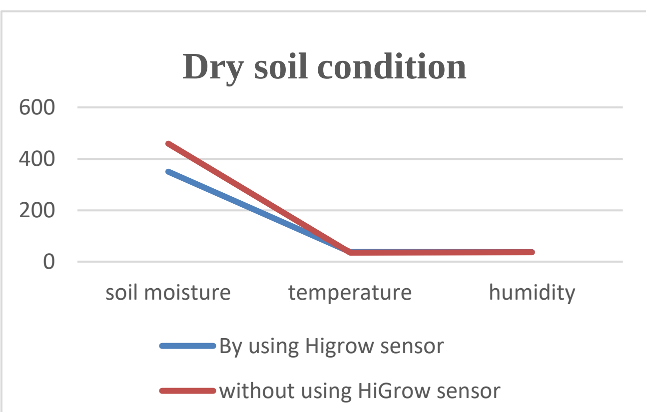


Fig-6: Soil moisture, Humidity and Temperature using HiGrow sensor



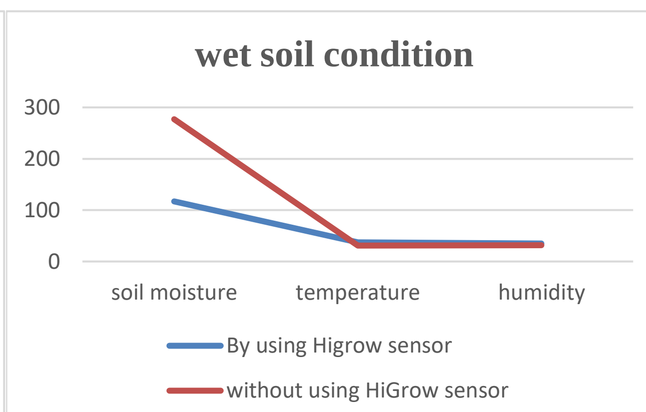


Fig-7: Soil moisture, Humidity and Temperature with and without HiGrow sensor in dry soil

Fig-8: Soil moisture, Humidity and Temperature with and without HiGrow sensor in wet soil

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CONCLUSION

In this paper design and analysis of "An Economical Battery-coupled Solar Water Pump using HiGrow Sensor Module" has demonstrated the potential of integrating renewable energy sources, battery storage, and automation technology to create a sustainable and cost-effective water pump system for agricultural use. The system's reliance on solar energy and battery storage reduces dependence on traditional power sources, leading to lower operational costs and promoting sustainable farming practices. The HiGrow sensor module has proven to be an effective tool for optimizing water usage by automatically detecting soil moisture levels and triggering the water pump when necessary. This automation not only ensures optimal water supply to plants but also reduces water waste, contributing to efficient water management.

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