Volume: 3 Issue: 5 Pages: 07-10

Renewable Energy-Powered Water Pumping System

[*1] Dimpal V Chaudhari, [2]Sejal S Chaudhari, and [3]Yogendra N Sonawane

[*1] Final Year Undergraduate Student, Department of Electrical Engineering, R.C. Patel Institute of Technology, Shirpur, Dhule, Maharashtra, India.

Article Info.
E-ISSN: 2583-6528
Impact Factor (SJIF): 5.231
Peer Reviewed Journal
Available online:
www.alladvancejournal.com

Received: 10/April/2024
Accepted: 20/May/2024

***Corresponding Author**
Dimpal V Chaudhari
Final Year Undergraduate Student,
Department of Electrical Engineering,
R.C. Patel Institute of Technology,
Shirpur, Dhule, Maharashtra, India.

Abstract
The global water demand is increasing constantly due to growing populations, which now account for 16.5% of all countries. Fossil fuel-derived electricity, which is used to pump this water, extends the pump’s life cycle and increases greenhouse gas emissions. As power electronics and drives have advanced, renewable energy sources like the sun and wind can now be used to generate electricity for water pumping, minimizing greenhouse gas emissions. This study proposes the use of renewable energy sources, such as solar and wind energy, to generate electricity to pump water underground to meet energy requirements without producing greenhouse gases. Photovoltaic cells receive energy from sunlight, which is then used to pump water. However, because sunlight is a natural resource, there are times when conditions like climate change or seasonal concerns like the rainy season prevent the solar panel from producing enough power to pump the entire amount of water. Similarly, wind turbines generate wind energy based on wind velocity, which can become insufficient at times due to climate challenges. Thus, the two types of energy sources are combined to provide a sufficient amount of power, and a hybrid system that utilizes both solar and wind energy to pump water is used. If however the energy generated by both sources is greater than or equal to what is needed, storage batteries are used to store the excess energy and supply.

Keywords: Solar System, Wind Turbines, Hybrid System, Storage Battery, Charge Controller

1. Introduction

India is home to an abundance of sustainable energy source, including solar radiation, sunshine, moderate wind speeds, hydropower, and biomass energy [1]. These resources provide the nation with a fantastic chance to use small-scale solar wind energy systems to meet its energy needs. The goal of the recently passed Indian Renewable Energy Act is to encourage the domestic development of hybrid and micro-wind power systems up to 20 W for stand-alone uses [1-2]. Climate change related issues with food, energy, and water security may be resolved by drip irrigation systems. According to this technology, farmers can overcome the obstacles of rain-fed farming by having a steady supply of water year-round. In addition to increasing crop yields, drip irrigation conserves water. Farmers' electricity expenditures can be drastically reduced by the electricity produced by solar-wind hybrid systems, especially in isolated farming locations. Farmers can lessen their dependency on overpriced and erratic traditional electricity sources by employing renewable energy sources. Farmers may be able to save money as an outcome, and this will also help to keep agricultural practices generally sustainable. Indonesia is primarily an agricultural nation, with a sizable portion of its land used for farming [3]. Finding water for crop irrigation has become more difficult for farmers because of the conversion of agricultural land into commercial and residential areas, especially during the dry season.

Small rivers or wells are frequently used by farmers in newly established agricultural areas to irrigate their land, but manually pumping water is not an effective way of manufacturing agricultural products. It is additionally challenging to employ motorized pumps on these newly developed agricultural lands because they are frequently distant from electrical energy supplies. The utilization of solar and wind power plant (SWPP) technology as a substitute for energy sources for agricultural water pumps. It claims that Indonesia has a large amount of solar and wind energy resources, which makes them appropriate for supplying water pumps in isolated agricultural areas [4]. Time and energy savings are achieved through the use of a system that pumps water, particularly in light of the growing population and water consumption.

2. Literature Review

To evaluate sunshine quantity precisely using a multi-specific tester, researchers used data from to June 2016 in Banda Aceh, Aceh Besar, and Meulaboh. There were specific measuring instruments on the device called "Light meter LX 1102 type" [5]. The researchers most likely took regular measurements within the allotted period to fully record variations in sun intensity, which is essential for knowing the solar resources that are available in these regions. The main goal of these studies was to measure sunshine intensity, which is an essential factor in figuring out weather in agricultural irrigation systems. Through the application of the unique features of the Light Meter LX 1102 type, which is intended for exact light intensity measurement, scientists may obtain important information regarding the amount of solar energy that might be captured [6].

In the study, a horizontal, three-bladed turbine type was selected to capture wind energy. According to this design, the turbine has three blades that are fixed to the rotor and are set up to rotate on a horizontal axis. This turbine's original design was developed with parameters and data in consideration. Interestingly, 10 m/s was the greatest wind velocity that was employed in the design calculations [7]. The main objective of the turbine's design was to produce one kilowatt (KW) of power. The researchers concluded that 2.6 meters would be the ideal rotor diameter for the turbine based on these specified criteria. Additionally, the turbine's tower height was fixed at 10 meters. These design decisions and specifications are very important because they have a direct impact on how well the turbine performs in capturing wind energy and producing the required amount of power [8]. A popular and efficient design for wind turbines, the horizontal three bladed layout is renowned for its stability and effectiveness in turning wind energy into electrical power.

The researchers used a set of carefully selected tools made to fit the particular needs of the study to carry out their experiment. Polycrystalline silicon solar panels, the main energy source used each panel had specified parameters, such as an 80-watt power output, a maximum voltage of 42 volts, the total cross-sectional area of these panels was 0.715 square meters [8-9]. Batteries with a 50-amp-hour capacity that run at 12 volts complemented the solar panels by giving us a way to store and use the solar energy that was captured. The batteries were converted into alternating current (AC) using an inverter that could handle up to 500 watts of power and operated between 11 and 13 volts DC [9]. The arrangement included a charger controller to control the charging and discharging procedures. Specific features of this controller included a low voltage disconnect of 11.6 volts to avoid excessive battery drain and a boost charge voltage of 14.5 volts for battery charging. With a rated input and output of 12 volts DC and 10 amperes, the charger controller ensured an effective and regulated energy flow [10]. The minimum necessary for the experiment guided the careful selection of equipment in terms of capacity and specifications, ensuring that each component was well-suited for the study's intended purpose. This comprehensive arrangement allowed the researchers to examine the photovoltaic cells' efficiency, batteries, inverter, and charger controller in a controlled and representative environment.

The data retrieval procedure was performed for measuring solar radiation using a multimeter device. The initial step is data collection, with the primary focus being on collecting solar radiation data. A multimeter made especially for measuring sun radiation is used to accomplish. This device records the voltage variation in solar panels under solar radiation.

3. Methodology

The methodology for implementing the hybrid solar-wind water pumping system involves a systematic approach encompassing literature system configuration, charge control management, energy storage, continuous water supply, and various considerations.

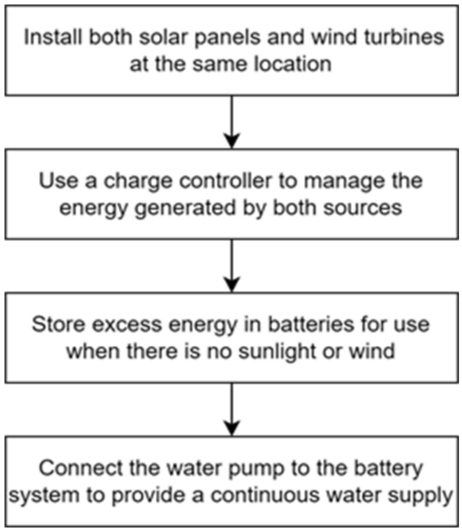

Fig 1: Methodology

1. System Configuration: Install solar panels and wind turbines at the same location, considering local sunlight conditions and wind characteristics. Ensure the coordinated operation of both energy sources.
2. Charge Control Management: Utilize a charge controller featuring both PWM regulation and MPPT technology to manage the energy generated by solar panels and wind turbines. Prevent overcharging and deep discharging of batteries.
3. Energy Storage: Incorporate deep-cycle batteries into the system to store excess energy generated during periods of high solar activity.
4. Continuous Water Supply: Connect the water pump to the battery system, ensuring a continuous water supply for agricultural purposes.

3.1 Solar Panel

The power output of a photovoltaic (PV) array, which is the amount of electrical energy it produces, is not constant and can change depending on various factors. Two important factors that affect the power output are solar radiation and temperature.

3.2 Specification

Table 1: Specification for Solar Panel

Detail	Solar Panel
Power Watt	20 W
Voltage Maximum Power	17.2 V
Maximum Power Current	1.03 A
Short Circuit Current	1.22 A
Open Circuit Voltage	23.5 V

3.3 Wind Turbine
In wind energy systems, turbines play a crucial role in converting the kinetic energy of moving air into mechanical energy, which can then be transformed into electricity. For small-scale renewable energy applications, like the 20W hybrid system we are focusing on, micro wind turbines are the appropriate choice. These turbines have a nominal power output ranging from 20 W to 500 W, making them suitable for powering individual homes or small appliances.

3.4 Specification

Table 2: Specification for Wind Turbine

Detail	Wind Turbine
Turbine of Diameter	0.28 M
Turbine of Height	0.61 M
Blade of Radius	0.14 M
Output Power	20 W

3.5 Charge Controller
This controller prevents overcharging and damage to the batteries by managing the voltage and current from the renewable sources. In a hybrid system, the charge controller must be versatile enough to handle inputs from both wind and solar components, making compatibility crucial.

3.6 Specification

Table 3: Specification for Charge Controller

T Detail	Charge Controller
Charge Controller type **a** **b**	1. PWM Regulator. 2. MPPT Charge Controller.
l Battery Temperature **e** Compensation	-4mV to -5mV/°C/cell
PV High Voltage	55V ± 2V
3Input Charging Current, Imax	40ADC± 2ADC
:Over Current cut-off with auto restart	>42ADC

3.7 Storage Battery
The controller's primary function is to ensure that the batteries are charged and discharged efficiently, considering the variable power generation patterns from both PV and wind sources throughout the day.

3.8 Specification

Table 4: Specification for Storage Battery

Detail	Storage Battery
Voltage	12 V
Charging Current	0.7-1.0 A
Capacity	7.5 Ah

3.9 Water Pump
Water pumping requirement refers to the amount of water that needs to be pumped for agricultural purposes. It is the demand for water needed to irrigate crops or provide water for livestock.

3.10 Specification

Table 5: Specification for Water Pump

Detail	Water Pump
Power Rating	0.05 Kw
Power Supply	12 V Dc
Motor Power	0.08 Hp

4. Implementation

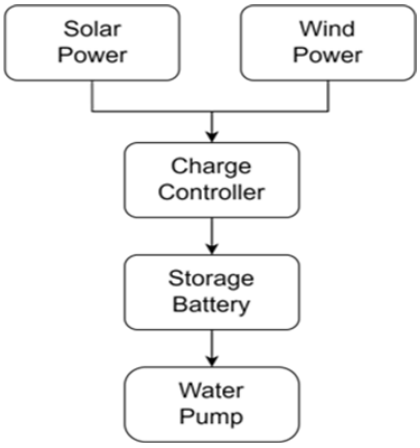

Fig 2: Block Diagram

This hybrid water pumping system adapts principles of solar-wind generation for optimized water pumping. Photovoltaic panels with sun-tracking maximize energy capture, while a multi-directional HAWT offers consistent mechanical power. Integrating batteries addresses intermittent renewable energy sources, ensuring continuous water supply via DC-powered pumps. This design prioritizes resilience and off-grid feasibility, offering a sustainable and eco-friendly solution for diverse water pumping needs.

4.1 Technical Description: Working Model
This hybrid water pumping system uses sun-tracking solar panels to grab every ray of sunlight, maximizing energy capture. A versatile wind turbine harvests energy from any wind direction, providing a continuous mechanical boost. Both sources feed a battery bank, storing excess energy for later use. When needed, this stored power fuels DC-powered pumps, ensuring an uninterrupted water flow regardless of fickle weather. It's like having a tireless team of sun-catchers and wind-whisperers keeping the water flowing, even in remote, off-grid settings.

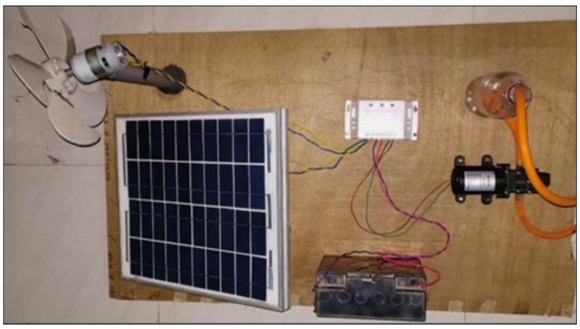

Fig 3: Working Model

4.2 Results
The results of the analysis provide insights into the hybrid system's performance, efficiency, and practical feasibility, considering the added dimension of energy storage. Together, these sources create a robust, complementary energy generation system that operates reliably in various conditions.

Fig 4: Result

Conclusion
In conclusion, the hybrid water pumping system, employing sun-tracking solar panels and a versatile wind turbine, demonstrates a promising solution for sustainable water supply. The synergistic integration of solar and wind power addresses the limitations of individual sources, providing continuous and reliable energy for pumping. The inclusion of a battery bank further enhances the system's efficiency, ensuring uninterrupted operation even in adverse weather conditions. This technology holds great potential for off-grid and remote areas, contributing to water accessibility and environmental sustainability.

References

1. Alimuzzaman, Md, Tariq Iqbal M. "Dynamic modeling and simulation of a 1kWwind turbine based water pumping system.", 2011, 4.
2. Divya K, Srinivasan S. "International Research Journal of Engineering and Technology (IRJET).", 2015, 14.
3. Harrouz A. *et al*. "Control of wind turbine based of PMSG connected to water pumping system in South of Algeria." 3rd International Symposium on Environmental Friendly Energies and Applications (EFEA). IEEE, 2014, 3.
4. Ghoneim Adel A. "Design optimization of photovoltaic powered water pumping systems." Energy conversion and management 47.11-12. 2006, 1449-1463.10.
5. Ones Lawrence E, Gustaf Olsson. "Solar photovoltaic and wind energy providing water." Global Challenges 1.5, 2017, 1600022.18.
6. Verma Shrey. *et al*. "Solar PV powered water pumping system–A review." Materials Today: Proceedings 46, 2021, 5601-5606.12.
7. Miranda Marcos S., David Infield. "A wind-powered seawater reverse-osmosis system without batteries." Desalination 153.1-3, 2003, 9-16.11.
8. Li Guiqiang. *et al*. "Research and current status of the solar photovoltaic water pumping system–A review." Renewable and Sustainable Energy Reviews 79, 2017, 440-458.8.
9. Shivrath Yandra *et al*. "Design & integration of wind-solar hybrid energy system for drip irrigation pumping application." International Journal of Modern Engineering Research (IJMER) 2.4, 2012, 2947-2950.9.
10. Bagloee, Saeed Asadi, Mohsen Asadi, Michael Patriksson. "Minimization of water pumps' electricity usage: A hybrid approach of regression models with optimization." Expert Systems with Applications 107, 2018, 222-242.