Hybrid Charging of UPS using Solar and Wind Energy

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Abstract

The growing demand for reliable and sustainable power solutions has driven the exploration of renewable energy sources. This paper presents a detailed analysis of a Hybrid Uninterruptible Power Supply (UPS) charging system that utilizes solar and wind energy. By integrating these renewable sources, the hybrid system ensures continuous power supply, reduces dependence on fossil fuels, and minimizes environmental impact. This research covers the design, implementation, and evaluation of the hybrid system, highlighting its economic and environmental benefits.

Keywords: Hybrid UPS, Solar Energy, Wind Energy, Renewable Energy, Sustainability

I. Introduction

Uninterruptible Power Supply (UPS) systems are vital for ensuring a continuous power supply in critical applications, including data centres, hospitals, and industrial operations. Traditional UPS systems rely heavily on grid power and batteries. This dependency not only incurs high costs but also poses environmental concerns due to the significant energy consumption and the utilization of non-renewable energy sources. The growing demand for reliable and sustainable power solutions has necessitated the exploration of alternative energy sources like solar and wind energy for UPS systems.

Renewable energy sources, particularly solar and wind, offer promising solutions to reduce dependence on fossil fuels and minimize environmental impact. Hybrid systems that integrate solar and wind energy can provide a more stable and reliable power supply by leveraging the complementary nature of these sources. Solar power is abundant during the day, while wind power can be harnessed both day and night, depending on weather conditions. By integrating these two sources, a hybrid UPS system can ensure a continuous and sustainable power supply.

II. Objectives of the Project

The primary objective of this project is to design and implement a hybrid UPS system that utilizes solar and wind energy for charging.

The specific goals of the project include:

- **System Design:** Develop a comprehensive design for a hybrid UPS system, integrating solar and wind energy components with the existing UPS infrastructure.
- **Component Selection:** Identify and select appropriate solar panels, wind turbines, charge controllers, batteries, and other components necessary for the hybrid system.
- **Implementation:** Install and configure the hybrid system, ensuring proper integration and functionality.
- **Performance Analysis:** Evaluate the performance of the hybrid UPS system in terms of efficiency, reliability, and cost-effectiveness.
- **Economic Evaluation:** Conduct a cost-benefit analysis to compare the hybrid system with traditional UPS systems, highlighting the economic advantages of renewable energy integration.
- **Environmental Impact Assessment:** Assess the environmental benefits of the hybrid system, including the

reduction in greenhouse gas emissions and other pollutants.

III. Components

1. Solar Panels

Figure 1: Polycrystalline Solar Panel

Solar panels, also known as photovoltaic (PV) modules, are responsible for converting sunlight into electrical energy. The efficiency and performance of solar panels depend on the type of PV cells used, which can be monocrystalline, polycrystalline, or thin-film.

2. Dynamo

Figure 2: Dynamo

A dynamo is an electrical generator that converts mechanical energy into electrical energy.

In the context of a wind turbine, the dynamo is driven by the mechanical rotation of the turbine blades, which are turned by the wind. When wind flows over the turbine blades, it causes them to rotate. This rotation turns the rotor of the dynamo, converting the kinetic energy of the wind into electrical energy.

3. Inverter

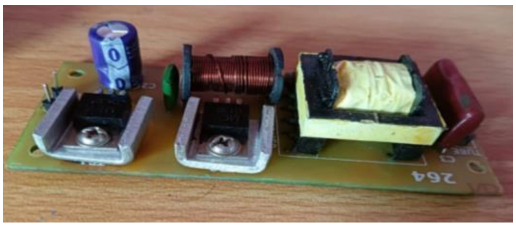

Figure 3: Inverter

An inverter board converts 12V DC power, which is common from battery storage in solar and wind energy systems, to 220V AC power, which is suitable for household appliances and is the standard voltage in many regions. The inverter board ensures that the power output is stable and reliable for various applications.

4. Battery

Figure 4: Battery

In a hybrid Uninterruptible Power Supply (UPS) system using solar and wind energy, lead-acid batteries are commonly used for energy storage. These batteries store the energy generated from renewable sources and provide power when the sources are not available.

5. Control Unit

Figure 5: Buck-Boost Converter

The control unit used is the Buck-boost converter, a type of DC-DC converter that can step up (boost) or step down (buck) an input voltage to a different level. This flexibility makes it ideal for applications where the input voltage can vary significantly such as Hybrid Ups.

6. Change over Switch

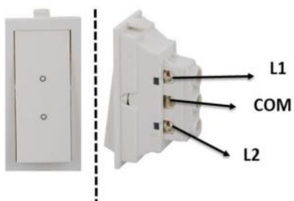

Figure 6: Change over switch

The primary function of a 2-pole manual changeover switch is to manually switch the power supply between two different sources. The switch has two separate circuits (or poles), each of which controls one of the two electrical paths. This allows it to switch both the live (hot) and neutral lines simultaneously to ensure proper and safe switching of the power supply.

IV. Working

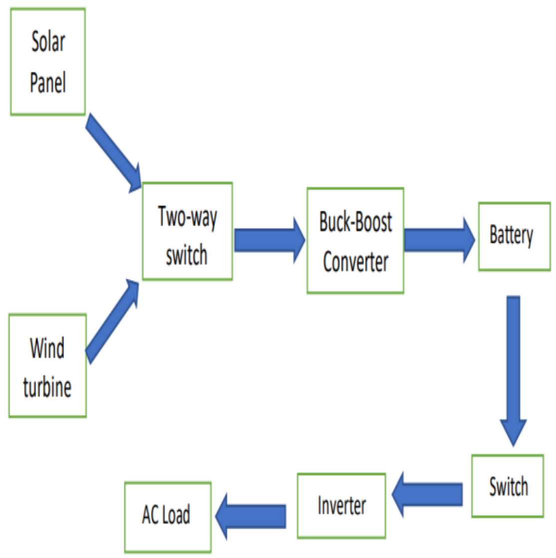

Figure 7: Block diagram of Hybrid Ups

During daylight hours, solar panels capture sunlight and convert it into DC electricity. When wind conditions are favourable, wind turbines generate DC electricity from the wind energy. The DC electricity from both solar panels and wind turbines is directed to the charge controller. The charge controller regulates the voltage and current going to the battery bank, ensuring optimal charging and preventing damage from overcharging. Batteries store power for utilization during times of low renewable energy output or grid failures as illustrated in Fig 7. An inverter subsequently converts the stored DC energy into AC power, suitable for operating electrical loads such as appliances and devices.

V. Hardware of the project

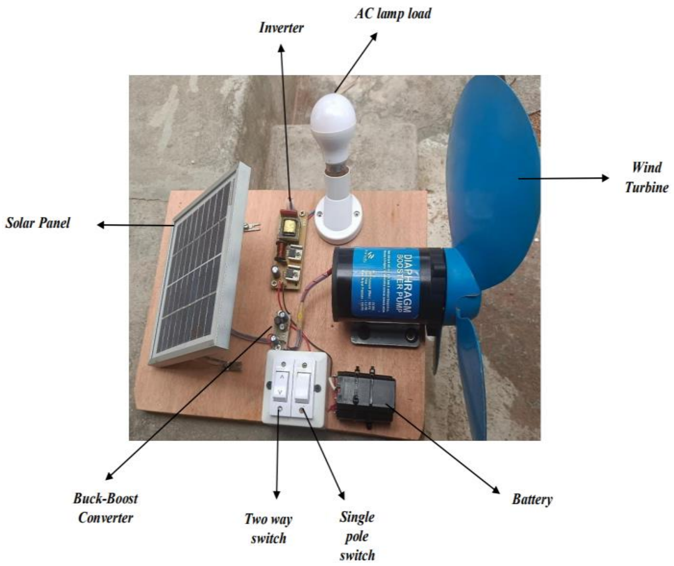

Figure 8: Hardware model

VI. Result

Performance Analysis of the Hybrid UPS system

1. Energy Generation and Utilization:

Solar Energy Production:

- ➢ Over a monitoring period of one month, the solar panels generated an average of 3W. The peak generation occurred during sunny days.
- ➢ Seasonal variations affected the output, with higher production in summer months and lower during winter.

Readings of output DC Voltage of Solar panel:

Time	Voltage (Volts)
10.00 AM	6 V
11.00 AM	6.5 V
12.00 PM	7.9 V
1.00 PM	10 V

Table 1: Shows the output DC Voltage of Solar panel

Wind Energy Production:

- The wind turbine produced an average of 7.4W, with significant fluctuations based on wind speed and weather conditions.
- During windy periods, the energy production spiked, compensating for lower solar output on cloudy days.

Readings of output DC Voltage of wind energy:

Wind speed in rpm	Velocity of the wind in meter/second	Voltage in Volts
490	2.93	13.3
610	3.11	15.8
666	3.15	18.2
715	4.30	20
795	4.11	21.5
980	4.17	24

Table 2: Shows the output DC Voltage of Wind energy

2. Battery Storage and Utilization:

- The battery bank effectively stores excess energy, ensuring continuous power supply during periods of low generation.
- The system maintained an optimal state of charge, with depth of discharge kept below 50%, enhancing battery lifespan and performance.
- The hybrid system's ability to integrate both sources resulted in higher overall efficiency and a more reliable energy supply.

VII. Advantages

- **Renewable Energy Utilization:** Utilizes abundant and sustainable resources, reducing reliance on non-renewable energy sources.
- **Enhanced Reliability:** Combines solar and wind energy to provide a more consistent and reliable power supply and also it ensures a continuous power supply by compensating for the intermittency of each source.
- **Cost Efficiency:** Reduces long-term operational costs by decreasing dependency on grid electricity and fossil fuels.
- **Energy Independence:** Provides autonomy from the grid, especially valuable in remote or disaster-prone areas where grid access is unreliable or non-existent.
- **Environmental Impact:** Reduces greenhouse gas emissions and pollution, contributing to a cleaner environment and combating climate change.

VIII. Conclusion

- **Enhanced Efficiency:** The hybrid UPS system effectively combined solar and wind energy to provide a more stable and reliable power supply than either source alone. This hybrid approach maximized energy capture and utilization, ensuring optimal performance.
- **Improved Reliability**: The integration of multiple renewable sources, along with a well designed battery storage system, significantly improved the reliability and availability of power. This makes the hybrid UPS system suitable for applications requiring uninterrupted power supply.
- **Economic Benefits:** Despite a higher initial investment, the hybrid system proved to be economically viable in the long run, offering substantial energy savings and a reasonable payback period. The system's low operational costs further enhance its cost-effectiveness over time.
- **Environmental Impact:** By harnessing renewable energy sources, the hybrid UPS system contributes to reduced

carbon emissions and a smaller environmental footprint compared to traditional fossil-fuel-based power systems

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