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Fabrication of Solar-Wind Hybrid Power Plant

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ABSTRACT: The globe is dealing with several issues like energy security, climate change, and economic sustainability. Though conventional energy sources are worldwide for the generation of energy, they have certain limitations like limited storage and pollution problems. Transportation issues so nowadays the world is looking for alternatives to conventional fuels. Renewable Energy sources are eco-friendly, and they are easily & abundantly available in nature. Solar and wind power are two examples of renewable energy sources that have been cited as important answers to these problems. It is challenging to produce a dependable and consistent power supply since these energy sources are unstable and irregular. Hybrid energy systems that mix solar and wind power have become an appealing answer to this problem. The design, functionality, and possible advantages of hybrid solar-wind energy systems are all covered in detail in this study.

KEYWORDS: Carbon based fuel, Hybrid system, Eco-friendly.

I. INTRODUCTION

We show our innovative ideas in our project. Here we utilized the solar +wind + human power (renewable energy).To generate the electricity for saving the fuel consumption up to 30 percent. Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished). In 2008, about 19% of global final energy consumption came from renewable, with 13% coming from traditional biomass, which is mainly used for heating, and 3.2% from hydroelectricity. New renewable (small hydro, modern biomass, wind, solar, geothermal, and biofuels) accounted for another 2.7% and are growing very rapidly. The share of renewable in electricity generation is around 18%, with 15% of global electricity coming from hydroelectricity and 3% from new renewable.

Man has needed and used energy at an increasing rate for his sustenance. Energy utilization increases due to rapid industrialization. Economy development of any country depend on the energy sources. So energy is the primary most universal measure of all kinds of work by human being and nature.

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Objective

1. To evaluate the benefits and challenges of a hybrid solar-wind energy system for renewable energy production.
2. To develop a mathematical model for optimizing the design of a hybrid solar-wind energy system based on system parameters such as solar panel area, wind turbine capacity, and battery capacity.
3. To investigate the impact of system parameters on energy production and cost.
4. To compare the performance of a hybrid solar-wind energy system with standalone solar and wind energy systems in terms of energy production, reliability, and cost.
5. To provide insights into the design and optimization of hybrid solar-wind energy systems for renewable energy production that can be applied in practical setting.

II. LITERATURE SURVEY

1. In a study conducted by Kumar et al. (2016), a hybrid solar-wind energy system was proposed for off-grid electrification in a rural area in India. The study found that a hybrid system could provide a more reliable source of electricity than a stand-alone solar or wind system, and could reduce the capital cost of the system
2. Another study conducted by Li et al. (2017) investigated the optimal sizing of a hybrid solar-wind system for a remote island in China. The study found that a hybrid system could reduce the cost of energy by up to 30% compared to a stand-alone solar or wind system, and could provide a more stable source of electricity
3. In a study conducted by Rizk et al. (2019), a hybrid solar-wind system was proposed for a residential building in Lebanon. The study found that a hybrid system could provide a more reliable source of electricity than a standalone solar or wind system, and could reduce the payback period of the system.
4. Analysing the literature review on the design and development of vertical axis wind turbine blades was done by D.A. Nikam. This essay illustrates how wind turbines, such as vertical and horizontal ones, are frequently used to produce electricity. The horizontal windmill is extensively utilised for large-scale applications that need more room and significant financial outlay. The vertical wind turbine, however, is inexpensive and suited for household use. The wind turbine's blade design and orientation have an impact on how much power is produced. Setting the appropriate parameter for the blade design will optimise this. The experimental finding suggests that the turbine's performance and energy output are significantly impacted by the blade.
5. Altab Hossain looked into the creation of a 1/3 size vertical axis wind turbine for the production of electrical power. In this study, wind energy and a belt power transmission system are used to generate electricity from a wind turbine. The wind turbine is built with a blade-to-drag device ratio of 1:3. Different wind speeds are used for the experiment, and the power generated by the windmill is determined. The testing findings show that although 709 W of power was created at a speed of 25 m/s, 567 W was produced at a speed of 20 m/s. Due to this, when the velocity is high, the power generation will increase.
6. Raj, E. Fantin Irudaya Polytechnica, December 2023 "This paper explores the integration of wind and solar energy technologies within the context of sustainable smart cities. It discusses the limitations of relying solely on non-renewable energy sources and emphasizes the benefits of hybrid solar-wind systems in enhancing energy reliability and efficiency. The study highlights the potential of these hybrid systems to meet the growing energy demands of urban environments while reducing environmental impact.

III. METHODOLOGY**1. Site Selection and Feasibility Study**

- Conduct a survey of potential locations with adequate sunlight and wind availability.
- Use anemometers and solar radiation meters to measure environmental conditions.
- Analyse geographical and meteorological data to determine feasibility.
- Ensure structural stability and minimal obstructions for maximum energy generation.

2. System Design and Component Selection

- Select an optimized Vertical Axis Wind Turbine (VAWT) based on aerodynamics and wind speed.
- Choose high-efficiency solar panels with suitable tilt angles for maximum absorption.
- Determine battery capacity, charge controller, and inverter based on load requirements.
- Develop a CAD model of the hybrid system for design validation.

3. Mechanical and Structural Setup

- Design and fabricate a supporting frame for the VAWT and solar panels.
- Conduct stress and load analysis on the structural frame using FEA (Finite Element Analysis).
- Mount the solar panels on an adjustable frame for seasonal angle adjustments.
- Set up shaft and bearing arrangements to reduce mechanical losses in the wind turbine.

4. Electrical System Integration

- Connect the solar panels and wind turbine to a charge controller to regulate power.
- Integrate a battery storage system to store excess energy for continuous operation.
- Use an inverter to convert DC power to AC, suitable for common applications.
- Implement a hybrid power management system with relays and automation.

5. Fabrication and Assembly

- Manufacture turbine blades using lightweight and durable materials (e.g., composite materials).
- Assemble the wind turbine rotor, stator, and supporting frame.
- Ensure proper alignment and balancing of rotating components.
- Conduct welding and machining processes for structural integrity.

6. Testing and Performance Analysis

- Conduct load testing under real environmental conditions.
- Measure voltage, current, and power output of the hybrid system.
- Evaluate aerodynamic efficiency of the turbine using CFD (Computational Fluid Dynamics).
- Assess efficiency under varying wind speeds and solar intensities.

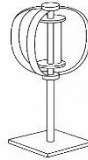
7. Optimization and Troubleshooting

- Identify and rectify mechanical vibrations, misalignments, or inefficiencies.
- Apply lubrication and damping techniques for smooth operation.
- Implement MPPT (Maximum Power Point Tracking) algorithms for solar optimization.
- Ensure automatic switching between solar and wind power sources for efficiency.

8. Final Implementation and Documentation

- Deploy the final hybrid system prototype and monitor its real-time performance.
- Maintain data logs for power generation, storage, and usage patterns.
- Document observations, efficiency calculations, and future scope.

1. Vertical Axis Wind Turbine (VAWT)



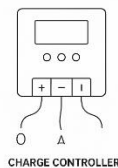
- Working: The turbine blades capture wind energy, rotating the central shaft, which in turn drives the generator to produce electricity.
- Key Parts: Blades, Rotor, Stator, Shaft, Bearings.
- Material: Aluminium/Composite for lightweight and durability.

2. Solar Panels



- Working: Converts sunlight into electrical energy using photovoltaic cells.
- Types: Monocrystalline/Polycrystalline.
- Efficiency: 15-22%.
- Mounting Structure: Adjustable Steel Frame for optimizing sun exposure.

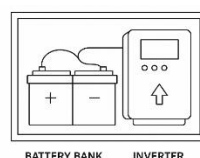
3. Charge Controller



- Working: Regulates power from wind and solar sources, preventing overcharging of batteries.
 - Type: MPPT (Maximum Power Point Tracking) for optimal energy harvesting.
- Function: Manages voltage and current flow to the battery.

4. Battery Bank

- Working: Stores excess energy from wind and solar sources for later use.
- Type: Lead-Acid or Lithium-ion.
- Capacity: Determined based on power requirement.
- Function: Ensures continuous power supply during low wind or nighttime conditions.



5. Inverter

Working: Converts DC power stored in the battery into AC power for use in electrical applications.

Type: Pure Sine Wave for efficiency and stability.

Function: Enables hybrid energy utilization for appliances and grid connection.

6. Mounting & Support Structure

Working: Provides stability and alignment to the wind turbine and solar panels.

Material: Mild Steel / Aluminium.

Foundation: Concrete or Steel Base for long-term durability.

7. Cabling and Connectors

Working: Transfers electrical energy efficiently between components.

Material: Insulated Copper Wires for conductivity.

Connectors: Weatherproof for long-term outdoor use.

IV. EXPERIMENTAL RESULTS

Test Condition	Solar Output (W)	Wind Output (W)	Combined Output (W)	Battery Voltage (V)
Sunny Day (No Wind)	18.5	0	18.5	12.6
Cloudy Day (Mild Wind)	6.2	5.8	12.0	12.1
Evening (Windy)	2.4	7.6	10.0	12.4
Midday (Sunny + Windy)	19.2	8.3	27.5	12.9

- The solar panel output was highly dependent on sunlight intensity, showing peak performance during midday.
- The wind turbine contributed more significantly when wind speed exceeded 3 m/s.
- The hybrid system effectively compensated for low solar or wind input by utilizing the alternative source.
- The battery was successfully charged in all scenarios, indicating efficient power management and storage.
- The testing confirms that the hybrid system can reliably generate and store electrical energy using both solar and wind resources. It offers a sustainable and flexible solution, especially in areas with variable weather conditions.

V. CONCLUSION

Hybrid solar-wind power generation is an innovative and highly effective approach to addressing the growing global demand for clean, reliable, and sustainable energy. By integrating photovoltaic (PV) solar panels with wind turbines, this hybrid system maximizes energy output by capitalizing on the complementary nature of solar and wind resources. While solar energy is most productive during daylight hours and in clear weather conditions, wind energy is often available during the night or in overcast and stormy conditions. This complementary behavior significantly enhances the overall efficiency and reliability of the power supply.

One of the key advantages of hybrid systems is their ability to ensure a more stable and continuous power output. In standalone solar or wind systems, intermittency is a major issue—solar energy drops at night and during cloudy periods, while wind energy can fluctuate or become unavailable in calm weather. A hybrid system mitigates these issues by providing backup from one source when the other is underperforming, thereby reducing the need for expensive energy storage or fossil-fuel-based backup systems.

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