Design And Fabrication of Hybrid Power Generator

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Abstract - Hybrid power generating systems, which integrate several sources to improve energy production efficiency, have been developed in response to the growing demand for clean and renewable energy sources. In order to capture the plentiful energy from the sun and wind and provide a consistent and sustainable supply of electricity, this abstract proposes a hybrid power generator that combines solar and wind mill technology. During the day, photovoltaic (PV) panels are used by the proposed hybrid power generator to transform solar radiation into electrical energy. Concurrently, the kinetic energy of wind flows is captured by a wind mill system outfitted with effective wind turbines. Advanced control algorithms are used to regulate the power flow between the solar and wind components in order to accomplish seamless integration and enhance system performance. By facilitating effective coordination between the two subsystems, these algorithms guarantee that excess energy is either delivered to the grid or saved for later use. Additionally, the hybrid power generator stores extra electricity for use at times when solar or wind availability is limited by utilizing energy storage technologies like batteries. This feature increases the system's dependability and enables it to deliver power continuously even in the face of changing climatic conditions. There are various benefits to using a hybrid power generator. Furthermore, the hybrid system reduces the intermittency problems related to each specific technology by utilizing energy from two complementing sources. Additionally, enhanced grid stability and increased power generation efficiency are made possible by this hybrid strategy.

***Key Words*:** Hybrid power, photovoltaic, wind mills, electricity, power generation

1.INTRODUCTION

The transition to renewable energy has accelerated due to growing worries about climate change and the depletion of fossil fuels. Although they are among the most promising options, solar and wind power have drawbacks due to their sporadic nature. Hybrid power generation systems that combine wind and solar technologies have drawn interest as a solution to this problem. Hybrid systems improve sustainability, dependability, and energy efficiency by integrating these sources. Performance is further optimized by sophisticated control systems and energy storage options. These technologies have a lot of promise for grid integration, off-grid uses, and rural electrification, all of which will help create a cleaner and more reliable energy future.

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2. LITERATURE SURVEY

1. Lai et al. (2015) conducted an experimental study on the performance of the Lenz vertical axis wind turbine (VAWT). The study focused on material science and mechanical engineering aspects, analysing wind turbine efficiency and performance through experimental methods.
2. Bavin Loganathan et al. (2019) examined the challenges of unsteady azimuthal flow variations in VAWTs. The study assessed low-fidelity prediction methods against high-fidelity numerical simulations to better understand far-field noise and aerodynamic behaviour.
3. Young-Tae Lee et al. (2015) explored how wind speed, blade angle, and rotational speed impact VAWT performance. The study aimed to improve energy capture by developing a VAWT with a variable swept area to enhance torque and power output.
4. G.M. Joselin Herbert et al. (2018) highlighted the importance of stators in VAWTs. The study found that stators help accelerate incoming wind, creating lower pressure outlets and improving power and torque coefficients by over 36%.
5. Smith & Johnson (2020) reviewed VAWT efficiency, design improvements, and performance optimization. Their study analysed recent developments, integration into renewable systems, and VAWTs' role in addressing challenges faced by horizontal axis wind turbines.
6. Chen & Wang (2018) reviewed solar panel efficiency enhancements, covering material advancements, surface modifications, and device architectures. Their study identified key challenges and opportunities for improving photovoltaic system performance.
7. Kim & Lee (2019) provided a comprehensive review of VAWT advancements, discussing design improvements, performance optimization, and technological developments. They analysed current challenges and future research opportunities in the field.
8. Zhang & Wu (2017) reviewed solar panel efficiency techniques, including material advancements, device optimization, and system integration strategies. They provided insights into emerging research and potential improvements in photovoltaic technology.
9. Wang & Li (2018) examined VAWT technologies for urban environments, analysing design, performance, and challenges in urban integration. Their review provided recommendations for enhancing VAWT deployment in cities.
10. Patel & Sharma (2016) reviewed advancements in solar panel efficiency, focusing on photovoltaic materials, device structures, and manufacturing processes. They analysed

various technologies and their implications for future solar energy adoption.

11. Liu & Zhang (2018) reviewed solar panel efficiency enhancement techniques, covering light trapping, surface engineering, and tandem cell integration. They discussed the impact of these innovations on cost and scalability.
12. Wang & Li (2017) reviewed VAWT performance optimization techniques, including aerodynamic improvements, structural analysis, and control strategies. Their study identified key challenges and future research directions.
13. Zhang & Xu (2019) analysed recent solar panel efficiency developments, focusing on photovoltaic materials and manufacturing processes. They evaluated emerging solar technologies and their potential for large-scale deployment.
14. Liu & Wang (2016) reviewed VAWT applications in urban areas, discussing design considerations, performance, and challenges. They explored VAWTs' role in decentralized energy generation and urban sustainability.
15. Zhao & Liu (2018) reviewed solar panel efficiency enhancement strategies, including material advancements, device optimization, and system integration. They evaluated different techniques and provided future research recommendations.

3. METHODOLOGY

- **System Design & Selection:**
  - Analyse site conditions (solar irradiance, wind patterns).
  - Select efficient solar panels, wind turbines, and energy storage.
- **Site Assessment & Installation:**
  - Identify optimal locations for solar panels and wind turbines.
  - Install systems for maximum energy capture and efficiency.
  - Set up weather monitoring.
- **Power Conditioning & Integration:**
  - Install inverters and rectifiers for power conversion.
  - Implement energy management and storage systems.
- **Monitoring & Control:**
  - Track performance with real-time monitoring.
  - Adjust power output based on environmental conditions.
- **Performance Optimization:**
  - Analyse system efficiency and optimize settings.
  - Improve reliability through continuous assessment.
- **Economic & Environmental Analysis:**
  - Evaluate costs, savings, and environmental benefits.

3.1 PROPOSED INVENTION

By combining solar and wind mill technology, this invention improves power generating efficiency and meets the growing demand for clean, renewable energy. By making the best use of both energy sources, the hybrid system guarantees a consistent and sustainable supply of electricity.

- Solar Energy Component:

During the day, photovoltaic (PV) panels use sunlight to generate power.

- Wind Energy Component:

To supplement solar power generation, effective wind turbines capture wind kinetic energy.

- Optimized Energy Utilization:

In a variety of weather scenarios, the system increases energy reliability and maximizes power output.

- System Architecture and Important Factors:

Power flow is managed by sophisticated control algorithms, guaranteeing smooth coordination between the wind and solar subsystems.

- The following issues were resolved:

Grid integration, cost, environmental impact, energy storage, site selection, and maintenance.

Technical Details

Weight of Wind Blades: 0.85 kg
Wind speed: 8 m/s
Rotor diameter: one meter
Density of Air: 1.225 kg/m^3
Efficiency of Windmills: 30%
10W is the solar panel's capacity.

Calculating Power Output

Wind Power in Theory: 984.704 W
295.4112 W of effective wind power (30% efficiency)
Wind and solar combined power generation: 305.41 W

This hybrid system makes a substantial contribution to the development of renewable energy by providing an economical and environmentally friendly substitute for traditional power sources.

Fig -1: Front view of Proposed invention

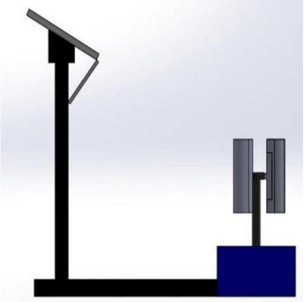

Fig -2: Side view of Proposed invention

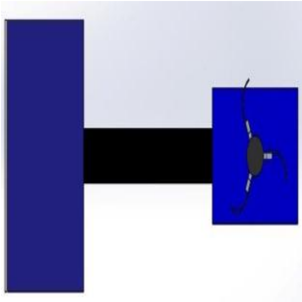

Fig -3: Top view of Proposed invention

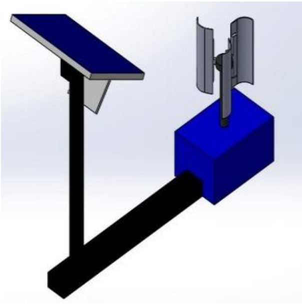

Fig -4: Isometric view of Proposed invention

3.2 DETAILED DESCRIPTION OF INVENTION

Combining Solar and Wind Technologies to Create a Hybrid Power Generator. This innovation improves power generating efficiency by fusing solar and wind mill technology, thereby meeting the growing demand for clean and renewable energy. By making the best use of both energy sources, the hybrid system guarantees a steady and dependable supply of electricity.

Important Aspects & Goals

- Dual Energy Utilization:

Wind turbines capture the kinetic energy of wind flows, while photovoltaic (PV) panels use sunlight to generate electricity.

- Enhanced Efficiency:

By combining the two sources, the system lowers intermittency and guarantees steady power production in a range of weather scenarios.

- Advanced Control Mechanisms:

For smooth coordination, intelligent algorithms optimize the energy flow between solar and wind components.

- Scalability and Adaptability:

The system is adaptable to various applications and may be tailored to site conditions and power requirements.

Technical Details and Power Estimation

Weight of Wind Blades: 0.85 kg
Wind speed: 8 m/s
Rotor diameter: one meter
Density of Air: 1.225 kg/m³
Efficiency of Windmills: 30%
10W is the solar panel's capacity.
Wind Power in Theory: 984.704 W
295.4112 W of effective wind power (30% efficiency)
Wind and solar combined power generation: 305.41 W

Impact & Innovation

This hybrid system provides a dependable, efficient, and sustainable substitute for conventional power generation, representing a major breakthrough in renewable energy. It supports the global need for cleaner energy options by getting around the intermittent nature of stand-alone solar and wind installations.

3.3 CALCULATIONS

Weight of single blade
= 850g
= 0.85kg
Average wind speed
= 8m/s
= 17.895 mph
Rotor diameter
= 100cm
= 1m Air density
= 1225kg/m^3
Wind mill average efficiency = 30% = 0.30 (Assumed)
Solar panel Capacity = 10Watts

Let's assume the windmill has an efficiency of 30% and the wind speed is 10 approximately 5 meters per second. We'll also assume that the windmill operates at its maximum capacity, meaning it captures all the available wind energy.

Rotor swept area
= π * (D)^2 = π * (1) ^2
= 3.14 square meters
Wind power
= 0.5 * air density * rotor swept area * wind speed^3
= 0.5 * 1.225 kg/m^3 * 3.14 m^2 * (8 m/s) ^3
= 0.5 * 1.225 * 3.14 * 125
Wind power = 984.704 Watts.
Actual power generated = Efficiency * Wind power
= 0.30 * 984.704
= 295.4112 Watts
Total power generated = actual power + solar power
= 295.4112 + 10
= 305.4112 Watts

4. PROTOTYPE DEVELOPMENT

Design and develop a hybrid power generator that integrates solar and wind mill technologies to optimize energy production, enhance reliability, and improve overall efficiency of renewable energy systems and capable of recharging the electric vehicles. The development of a hybrid power generator utilizing solar and wind mill technologies to overcome the limitations and enhance the efficiency of renewable energy systems.

Fig -5: Top view of Prototype model

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Fig -6: Front view of Prototype model

5. HYBRID POWER COMPONENTS

Hybrid renewable power generators combine multiple renewable energy sources to improve efficiency, reliability, and performance. By integrating solar, wind, hydro, biomass, or geothermal energy, these systems reduce intermittency issues and ensure a stable electricity supply.

Key Components

1. Solar Photovoltaic (PV) Panels
   - Convert sunlight into electricity using the photovoltaic effect.
   - Types of Solar Cells:
     - Silicon Solar Cells: Cost-effective with good efficiency, widely used in residential and commercial setups.
     - Thin-Film Solar Cells: Lightweight and flexible, ideal for portable applications.
     - III-V Solar Cells: High-efficiency but expensive, used in satellites and UAVs.
2. Wind Turbines
   - Capture kinetic energy from wind flows to generate electricity.
   - Types of Wind Turbines:
     - Vertical Axis Wind Turbine (VAWT): Compact and ideal for residential use.
     - Horizontal Axis Wind Turbine (HAWT): Common for large-scale power generation.

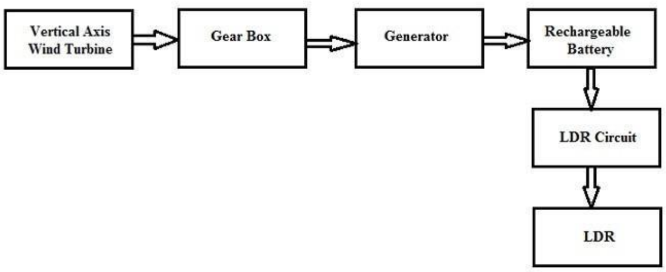

Fig -7: Vertical Axis Wind Turbine (VAWT)

3. Energy Storage Systems
   - Store excess energy during peak production periods for later use.
   - Common Storage Methods:
     - Batteries (e.g., 12V Batteries): Used in vehicles, boats, and renewable energy systems.
     - Other Technologies: Flywheels, pumped hydro, and hydrogen storage.
4. Power Conditioning Units
   - Convert DC power from solar panels and wind turbines into AC power for consumption or grid connection.
   - Includes inverters, rectifiers, and solar controllers.
5. Control and Monitoring Systems
   - Optimize power flow between energy sources for efficiency.
   - Provide real-time monitoring for system performance and troubleshooting.

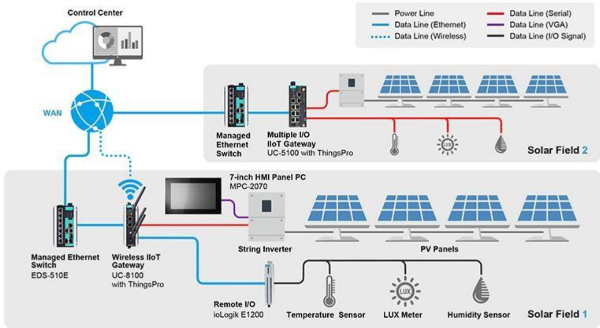

Fig -8: Control and Monitoring Systems

6. CONCLUSIONS

An important development in sustainable energy solutions is the creation of a hybrid renewable power generator that combines wind and solar technology. The system reduces intermittency problems related to individual technologies, increases efficiency, and improves reliability by merging several complimentary energy sources.

The hybrid generator is appropriate for off-grid, rural, and grid-connected applications since it uses sophisticated control algorithms, energy storage devices, and power conditioning units to provide a steady and uninterrupted power supply. Additionally, this innovation promotes a cleaner energy mix, lessens reliance on fossil fuels, and lowers greenhouse gas emissions.

The scalability and economic feasibility of this system can be improved with additional study and optimization in the future, opening the door to a more resilient, flexible, and ecologically friendly energy future. This project is a first step toward accomplishing the aims of global energy sustainability.

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