Design of Wind- Solar Hybrid Power Generation For Small Applications

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***Abstract*- This project presents a design for a wind-solar hybrid power generation system suitable for small-scale applications, such as homes, farms, or remote communities. The system integrates wind turbines and solar photovoltaic (PV) panels to provide a reliable and efficient source of renewable energy. The design optimizes energy production by leveraging the complementary nature of wind and solar resources, reducing dependence on a single energy source. A battery storage system is incorporated to ensure stable power output during periods of low wind or solar irradiance. The system's performance is evaluated using simulation models and experimental data, demonstrating its potential to provide a sustainable and cost-effective solution for small-scale power generation. The design can be tailored to meet specific energy demands, making it an attractive option for off-grid or grid-tied applications.**

I.INTRODUCTION

The increasing global demand for energy, coupled with concerns about climate change and fossil fuel depletion, has driven the development of renewable energy systems. Wind and solar power have emerged as promising alternatives due to their abundance and sustainability. However, the intermittent nature of these sources can lead to reliability issues when used individually. A hybrid system combining wind and solar power can mitigate these limitations, providing a more stable and efficient energy supply.

Small-scale applications, such as homes, farms, and remote communities, often face unique energy challenges due to limited access to grid power or high energy costs. A wind-solar hybrid power generation system can offer a reliable and cost-effective solution for these applications, reducing dependence on fossil fuels and lowering energy costs.

This project focuses on designing a wind-solar hybrid power generation system tailored for small-scale applications. The system integrates wind turbines and solar photovoltaic (PV) panels with a battery storage system to ensure stable power output. By leveraging the complementary nature of wind and solar resources, the system can provide a reliable and efficient source of renewable energy.

The design considerations, system components, and performance evaluation of the wind-solar hybrid power generation system will be discussed in detail. This introduction sets the stage for exploring the potential of hybrid renewable energy systems in addressing the energy needs of small-scale applications.

Many countries are actively exploring wind energy conversion systems to reduce dependence on fossil fuels. Additionally, numerous photovoltaic (PV) solutions globally provide power for small, remote, off-grid, or standalone applications. However, both solar and wind energy systems are highly dependent on meteorological conditions, including sunlight and average annual wind conditions at specific locations. The power output of a PV system is notably affected by weather conditions. For instance, during cloudy periods or at night, a PV system may not generate power. Furthermore, storing the generated power for later use presents challenges. To address this, PV systems can be integrated with alternative power sources and storage systems, such as electrolysis, hydrogen storage tanks, and fuel cell systems. Combined wind and solar systems are gaining popularity for standalone power generation due to advances in renewable energy technologies. The economic aspects of these technologies show promise for inclusion in developing power generation capacity, especially for developing nations. Continuous research and development are essential to enhance the performance of solar, wind, and other renewable energy technologies, accurately predict their output, and seamlessly integrate them with conventional power sources. Concerns about global warming and the depletion of fossil fuel reserves have intensified the focus on sustainable energy solutions.

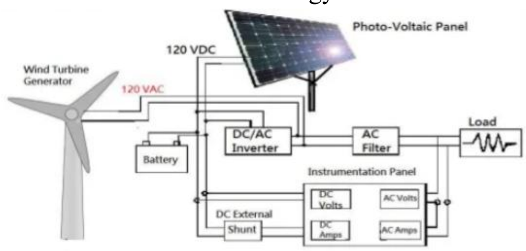

Fig: Hybrid solar wind power generation system

II. METHODOLOGY

Block diagram of the system The system's block diagram includes a solar panel, buck converter, and battery. The solar panel is responsible for converting solar energy into electrical energy, possessing a standard voltage rating of 12V. The conversion principle employed is the Photoelectric Effect. This phenomenon occurs when light strikes a material surface, causing electrons in the valence band to absorb energy and become excited, jumping to the conduction band and becoming free. Some of these electrons encounter a junction, where they are propelled into a different material by a Galvani potential. This process generates an electromotive force, producing electric energy. The buck converter, a type of dc-dc converter, consists of components such as a MOSFET switch (IRF250N), Inductor, capacitor, and diode. Its primary function is to decrease the input voltage.

Modeling a Photovoltaic (PV) System A PV system consists of an assembly of solar cells, connections, protective components, supports, and other associated elements. Solar cells are typically crafted from semiconductor materials, often silicon. These materials undergo special treatments to establish an electric field within the cell. One side of the cell becomes positively charged (rear), while the other side becomes negatively charged (facing the sun). Components of a Hybrid System: Photovoltaic (PV):Photovoltaic cells utilize semiconductor materials, typically silicon. When sunlight strikes these materials, electrons are dislodged, allowing them to flow through the material, creating an electric current and generating electricity.

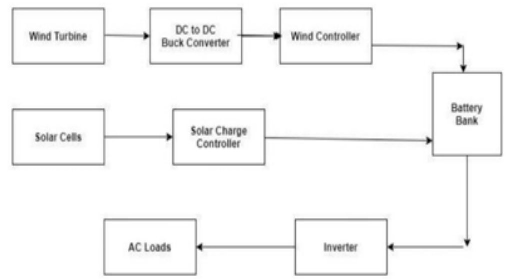

Fig: Block Diagram

Wind Turbine:Wind turbines harness wind energy to produce electricity. The interaction of lift and drag forces on turbine blades, caused by the wind, sets the rotor in motion. The rotating shaft then turns a generator, converting mechanical energy into electricity. Inverter:An inverter is a circuit that converts direct current (DC) into alternating current (AC). It serves as the intermediary between the PV arrays and the load, facilitating the use of the generated electricity. Converter:A converter is a circuit that transforms variable DC supply into controlled DC supply. It plays a role in managing and regulating the direct current within the system. Battery:Batteries are employed to store excess energy generated when production exceeds demand. They release stored energy to the load when demand surpasses generation, ensuring a balanced and reliable power supply. Permanent Magnet Synchronous Generator (PMSG):PMSG's are commonly employed to convert the mechanical power output of turbines into electrical power. In a PMSG, the rotor contains magnets, and the stator is a stationary armature electrically connected to a load. This arrangement facilitates the generation of electrical power from the rotation of the assembly. These components collectively form a hybrid system that integrates both solar and wind energy sources, providing a versatile and sustainable solution for power generation.

III. WORKING

When the solar rays are incident on the solar PV panel it will generates the electricity. The generated solar energy is stored in the battery through the charge controller. Meanwhile the small wind turbine also generates the electric energy and stores the energy in to the battery through charge controller. Solar and wind hybrid power systems are designed to generate electricity using solar panels and small wind turbine generators. Generally, these solar-wind hybrid systems are capable of small capabilities. Solar wind hybrid systems' typical power generation capacities range from 1 kW to 10 kW. The following block diagrams explain the working of the system. The stored energy into the battery will be utilized by connecting to the electric load (LED bulb).

In the solar PV panel, it comprises the solar cells which is used to convert the solar energy into the electric energy. The electrons produced in the N-type material are passed to battery through the wires and electrodes. Output of the solar panel is in the electric energy form and it is measured in the Watt. The different solar panels are designed for the various output rating. Based on the application/requirements we can use the different solar panel. A 12 volt 15 Watt solar panel produce around 1 Ampere current during the normal sunshine day. The life of the solar panel may vary from the manufacture to manufacture however the average life is around the 22 years. Efficiency of the solar panel may enhance by keeping the solar panel always normal to the Sun rays. The surface of the solar panel needs to clean at regular interval of the time. In summary, the pursuit of designing and implementing a Solar-Wind Hybrid System marks a significant step towards sustainable and resilient energy solutions.

Fig: Solar Panel

Fig: Experimental setup.

IV. CONCLUSION

This innovative approach addresses the challenges faced in extending conventional grids to rural areas, where economic feasibility and environmental concerns are paramount. The decision to combine solar and wind energy sources in a hybrid system reflects a commitment to versatility and efficiency. Through meticulous design and implementation, this hybrid system has demonstrated its capability to harness the strengths of both solar and wind power, ensuring a consistent and reliable energy supply even in remote or off-grid locations. The economic benefits of this hybrid system are evident, offering a cost-competitive and efficient solution for rural electrification. By tapping into renewable sources, it not only contributes to environmental conservation by reducing greenhouse gas emissions but also fosters local employment, thus elevating overall social welfare and living conditions. This project not only provides a blueprint for effective energy solutions but also contributes significantly to the global transition to cleaner and more resilient energy frameworks. In conclusion, the successful realization of the Solar Wind Hybrid System represents a beacon of hope for energy access in remote areas. Its impact extends beyond electricity provision, serving as a model for future projects that prioritize sustainability, efficiency, and positive social impact.

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