# Development of a Portable Hybrid Renewable Energy System for Sustainable Electricity Supply to Rural Communities in Nigeria

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## Abstract

The need for sustainable and reliable electricity supply in rural communities of Nigeria remains a pressing issue, given the country's vast energy deficit and the significant number of inhabitants lacking access to electricity. This research focuses on the development of a portable hybrid renewable energy system designed to provide a sustainable and efficient electricity supply to these underserved regions. The proposed system integrates multiple renewable energy sources, specifically solar and wind, to harness the abundant natural resources available in Nigeria. The design and development process involves the selection and optimization of components such as photovoltaic panels, wind turbines, energy storage units (batteries), and power management systems. These components are chosen based on their suitability for rural environments, cost- effectiveness, and ease of maintenance. The hybrid system is designed to be portable, allowing for easy transportation and deployment in remote locations with limited infrastructure. Key to the system's effectiveness is its hybrid nature, which ensures continuous power supply by compensating for the intermittent nature of individual renewable sources. Solar energy is harnessed during the day, while wind energy is captured whenever wind conditions are favourable, thus ensuring a more stable and reliable energy output. Energy storage units are critical in this setup, storing excess energy generated during peak production times and supplying power during periods of low renewable generation. A significant part of the research involves conducting feasibility studies and simulations to evaluate the performance of the hybrid system under various climatic conditions typical of different regions in Nigeria. These studies include assessing the solar irradiance, wind speed patterns, and energy consumption needs of rural communities. The simulation results inform the optimization of the system's design to maximize energy efficiency and reliability. This paper presents the development and evaluation of a 4 kW standalone hybrid system combining wind and solar power. The portable device measures approximately 1.5 metres in width, 1.2 metres in depth, and around 5.5 metres in height. It includes four solar panels with a capacity of 120 watts each, a 1.5 kW wind turbine, a solar charge controller, remote power storage, batteries, and battery control mechanisms. Designed to operate independently of the grid, this hybrid device offers versatility for use in highways and various other applications. It also presents a summary and characterization of the device, along with photovoltaic data collected in Nigeria during the month of April. The construction plan for the hybrid energy tower is outlined, which involves combining a vertical-axis wind turbine with solar panels to harness both wind and solar energy. Positioned between the roadway divider and automobiles, the tower takes advantage of the air velocity generated by passing vehicles. The solar panels are strategically mounted to deflect air towards the turbine while generating energy. Generators and gear systems attached to the turbine shaft enable power generation, offering a portable solution to energy challenges in Nigerian communities. The study also addresses the economic feasibility of the system, considering the initial investment costs, maintenance, and potential savings from reduced fossil fuel use. A comparative analysis with traditional energy supply methods highlights the long-term benefits and sustainability of the hybrid system.

## Keywords

Renewable energy, Solar panel, Wind Turbine, hybrid system, Generator.