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SOLAR WIND HYBRID POWER GENERATION ON HIGHWAY

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Abstract: This project presents the design and implementation of a solar–wind hybrid power generation system on highways aimed at utilizing renewable energy sources efficiently. Solar panels capture energy from sunlight, while wind turbines generate power from airflow created by moving vehicles and natural wind. The combination of solar and wind energy ensures reliable and continuous power generation throughout the day and night.

The generated electrical energy can be used for highway lighting, traffic signals, toll booths, and nearby public utilities, thereby reducing dependency on conventional fossil-fuel-based power sources. This system helps in lowering carbon emissions, minimizing energy losses, and promoting sustainable infrastructure development. The proposed hybrid power generation model is cost-effective, eco-friendly, and contributes to the effective utilization of unused highway spaces, supporting the goal of clean and renewable energy generation.

Keywords: Solar Energy, Wind Energy, Hybrid Power Generation, Highway Energy System, Renewable Energy, Battery Storage, Inverter, Sustainable Infrastructure

I. INTRODUCTION

Renewable energy sources are increasingly important due to rising energy demands and environmental concerns. Highways provide vast unused spaces and continuous airflow, making them ideal for installing renewable energy systems. A solar–wind hybrid power generation system utilizes both solar and wind energy to ensure continuous and reliable power generation. By integrating these two sources, the limitations of individual systems are minimized, resulting in improved efficiency and sustainability.

II. LITERATURE SURVEY

In recent years, renewable energy systems have gained significant attention due to the increasing demand for electricity and growing environmental concerns. Among various renewable solutions, solar–wind hybrid power generation systems have been widely studied because they offer higher reliability and efficiency compared to standalone solar or wind systems. Researchers have highlighted that the intermittent nature of solar and wind energy can be effectively managed by combining both sources, ensuring continuous power generation under varying climatic conditions.

Several recent studies focus on the utilization of highways as potential sites for renewable energy generation. Highways provide large unused spaces and experience continuous airflow due to moving vehicles, making them suitable for installing solar panels and wind turbines. Research conducted in the last few years indicates that vertical-axis wind turbines (VAWTs) are more suitable for highway applications as they can operate efficiently at low wind speeds and are less affected by wind direction. When integrated with solar photovoltaic systems, the overall energy output is significantly improved.

Recent techno-economic analyses show that solar–wind hybrid systems installed along highways can effectively supply power for street lighting, traffic signals, toll plazas, and electric vehicle charging stations. Simulation-based studies using tools such as MATLAB and HOMER have demonstrated improved system reliability, reduced power fluctuations, and lower dependency on grid electricity. Moreover, these systems contribute to reduced carbon emissions and promote sustainable infrastructure development.

III. METHODOLOGY

The methodology of the solar–wind hybrid power generation system on highways involves the integration of solar and wind energy sources to ensure efficient and continuous power generation. The system is designed to capture solar energy

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using photovoltaic (PV) panels and wind energy using wind turbines installed along the highway where sufficient sunlight and airflow from moving vehicles are available.

Initially, the solar panels convert sunlight into DC electrical energy, while the wind turbines generate electrical power from wind energy. The outputs from both sources are fed into a hybrid charge controller, which regulates voltage and current levels and ensures safe charging of the battery system. This controller also prevents overcharging and deep discharging of the batteries.

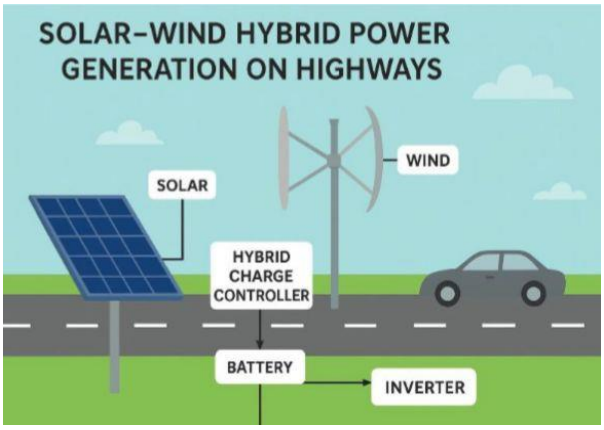

Figure 1: Block diagram of Solar–Wind Hybrid Power Generation System

IV. RESULTS

The solar–wind hybrid power generation system on highways was successfully designed and analyzed to evaluate its performance and feasibility. The results show that the hybrid system is capable of generating electrical power efficiently by utilizing both solar and wind energy sources. During daytime, solar panels contributed the major share of power generation, while wind turbines provided additional energy during low sunlight and nighttime conditions.

The integration of both energy sources improved overall system reliability and reduced power fluctuations compared to standalone solar or wind systems. The battery storage system effectively stored excess energy and supplied power during periods of low generation, ensuring uninterrupted power supply to highway loads such as street lighting and traffic signals.

The use of a hybrid charge controller ensured proper regulation of voltage and current, preventing overcharging and enhancing battery life. The inverter delivered stable AC output suitable for practical highway applications. Overall, the system demonstrated reduced dependency on grid electricity, lower operational costs, and minimized environmental impact, proving that solar–wind hybrid power generation on highways is a reliable and sustainable solution.

Figure 2: Experimental prototype of Solar–Wind Hybrid Power Generation System on Highway

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V. CONCLUSION

The solar–wind hybrid power generation system on highways proves to be an effective and sustainable solution for meeting the growing energy demands. By combining solar and wind energy, the system ensures continuous and reliable power generation under varying environmental conditions. The utilization of highway spaces for renewable energy generation makes efficient use of available resources without affecting transportation activities.

The results show that the hybrid system reduces dependency on conventional power sources, lowers carbon emissions, and provides cost-effective energy for highway applications such as lighting and traffic signals. With proper design, energy storage, and control mechanisms, this system can play a significant role in promoting eco-friendly infrastructure and supporting future renewable energy development.

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