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Smart Renewable Energy System for Highways Using VAWT, Solar and Smart Applications

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Abstract: The demand for clean, renewable, and uninterrupted energy is rapidly increasing across the globe. This project presents a hybrid energy generation system designed for highway environments, utilizing both vertical axis wind turbines (VAWT) and solar panels to harvest energy from natural resources and vehicular movement. The wind energy is captured through the VAWT placed along the divider where air disturbance from passing vehicles is prominent, while solar panels capture sunlight during the day. The collected energy is stored in a battery and utilized for various applications such as automatic street lighting, electric vehicle charging, and wireless mobile charging. This dual-source system enhances power reliability and reduces dependency on non-renewable sources. The overall aim is to develop an efficient, eco-friendly energy system that supports smart highway infrastructure and aligns with sustainable development goals.

Keywords: Hybrid energy, vertical axis wind turbine (VAWT), solar power, smart street lighting, EV charging, wireless charging, renewable energy, highway infrastructure.

I. INTRODUCTION

With the ever-growing demand for sustainable energy and increasing environmental concerns, the use of renewable energy sources has become more critical than ever. Among the various options, solar and wind energy have proven to be the most reliable and accessible. Highways, being long stretches of open space with constant vehicle movement and abundant sunlight, offer a great opportunity to harness both wind and solar energy simultaneously.

This project aims to design a hybrid energy generation system that integrates a vertical axis wind turbine (VAWT) and solar panels to produce clean energy. The VAWT captures wind generated by the motion of vehicles on the highway, while the solar panels absorb sunlight throughout the day. The generated power is stored in a battery system and used to support multiple applications such as automatic street lighting, electric vehicle (EV) charging, and wireless charging pads.

The proposed system is highly beneficial in rural and semi-urban areas where grid power is unreliable or unavailable. It reduces dependence on fossil fuels and contributes to the development of smart and sustainable highway infrastructure. This project not only focuses on power generation but also on its efficient utilization in modern-day applications that promote energy efficiency and environmental sustainability.

II. LITERATURE SURVEY

1. "Hybrid Solar and Wind Energy Generation System for Highway Applications" discusses an integrated renewable energy model where vertical axis wind turbines (VAWTs) and solar panels are installed along highways to harness energy from passing vehicles and sunlight. The system efficiently stores generated power in batteries for later use in street lighting and traffic systems. The authors highlight how using VAWTs is more effective in variable wind conditions typically found near highways. This paper supports the feasibility and reliability of combining two renewable sources for continuous energy generation in transport infrastructure. [1]

2. "Design and Simulation of Vertical Axis Wind Turbine for Low Wind Speed Conditions" focuses on optimizing the blade design of a VAWT for areas where wind is weak or inconsistent, such as urban or roadside environments. The study uses simulation tools to compare H-type and Darrieus rotor blade configurations. Results show that small-scale turbines with optimized airfoil design can still generate usable energy. This research validates the efficiency of compact VAWTs in practical applications like roadside energy harvesting. [2]

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3. "Solar Street Light Control System Based on Arduino" proposes a smart lighting system that automatically switches ON/OFF street lights using an LDR (Light Dependent Resistor) and real-time clock modules. The system is Arduino-based and powered by solar panels, minimizing energy wastage and power grid load. The paper provides relevant insights for incorporating automatic street lighting into highway energy systems. It confirms how renewable-powered smart lighting contributes to safety and energy efficiency. [3]

4. "EV Charging Stations Powered by Hybrid Energy Systems" evaluates how roadside solar and wind systems can power public EV charging infrastructure. The paper includes load analysis, battery sizing, and inverter design. It demonstrates the scalability of hybrid power setups in supporting fast and trickle EV charging without relying on the main grid. This literature supports integrating your project's stored power into practical EV charging use. [4]

5. "Wireless Charging of Electric Two-Wheelers Using Inductive Coupling" introduces the concept of a wireless charging pad that uses resonant inductive coupling for short-range energy transfer. The setup includes a transmitter coil embedded in the road and a receiver coil under the vehicle. While efficiency is lower than plug-in charging, the convenience and safety make it ideal for compact systems. This paper aligns with your proposed wireless charging application for 2-wheelers or portable devices. [5]

6. "Optimization of Power Storage in Hybrid Renewable Systems" explains how to control the flow of power between solar/wind inputs, charge controllers, and batteries. The paper proposes using microcontrollers to dynamically balance input power with load demand, ensuring longer battery life and efficient energy use. This supports the idea of managing multiple outputs in your project (lighting + charging). [6]

7. "Highway Smart Poles Powered by Renewable Energy" describes the use of smart poles that combine solar panels, wind turbines, and IoT-based systems for lighting, surveillance, and charging. The smart poles also house public Wi-Fi and pollution sensors, creating a complete smart infrastructure node. The concept reinforces how renewable hybrid systems can do more than just lighting, which fits perfectly with your project's multi-output goal. [7]

III. APPLICATIONS

1. Automatic Street Lighting: The energy generated by the hybrid system is stored in batteries and utilized to power smart street lights along the highway. This ensures efficient lighting during nighttime without relying on the grid.

2. Electric Vehicle (EV) Charging: The system supports charging ports that allow electric two-wheelers and small EVs to be charged using the stored renewable energy. This promotes clean transportation and reduces range anxiety on highways.

3. Wireless Charging: A wireless charging pad can be integrated using inductive coupling to provide cable-free charging for mobile devices or small electric vehicles, enhancing user convenience.

4. Highway Surveillance & Sensors (optional enhancement): The generated power can also support low-power highway surveillance cameras, pollution monitoring systems, or weather sensors, enabling smart infrastructure in future upgrades.

IV. PROBLEM IDENTIFICATION

The increasing demand for electricity and the environmental impact of non-renewable energy sources have raised concerns about sustainable development. Traditional highway lighting and infrastructure systems are heavily dependent on grid power, which is not only costly but also unreliable in remote or rural regions. Additionally, there is a lack of integrated systems that can utilize natural resources like wind and solar energy simultaneously for real-time applications such as street lighting and EV charging.

Moreover, conventional renewable energy setups either rely on single sources or require large-scale installations that are not feasible for roadside or divider-based deployment. There is also minimal utilization of vehicle-induced wind energy, which remains an untapped resource along busy highways. These challenges highlight the need for a compact, efficient, and hybrid renewable energy system capable of powering essential services along highways while promoting sustainability.

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V. FUTURE SCOPE

The proposed hybrid renewable energy system has significant potential for future development and expansion. In the future, this setup can be scaled to support high-capacity electric vehicle (EV) charging stations along expressways and highways, promoting green mobility across larger distances.

Additionally, the system can be integrated with IoT-based monitoring for real-time power management, predictive maintenance, and remote diagnostics. Wireless energy transmission for EVs and public devices can be improved using advanced inductive and resonant charging techniques. The incorporation of energy analytics and AI can further optimize energy harvesting based on traffic flow and weather conditions.

Furthermore, this model can be replicated in smart cities, border highways, and emergency corridors where grid power is inaccessible or unreliable, thereby contributing to national renewable energy goals and intelligent transportation systems.

VI. CONCULSION

. This project presents a sustainable and practical solution for utilizing renewable energy sources along highways through the integration of vertical axis wind turbines and solar panels. The hybrid system effectively captures wind energy generated by moving vehicles and solar energy during the day, thereby ensuring consistent power generation.

The energy stored is successfully used to operate essential highway services such as automatic street lighting, electric vehicle charging, and wireless charging applications. By reducing dependency on conventional grid power and fossil fuels, this system promotes energy efficiency, environmental sustainability, and smart infrastructure development.

The proposed design is economical, scalable, and environmentally friendly, making it a viable option for deployment in both urban and rural highway networks. It serves as a step forward toward the realization of self-powered smart highways and supports the larger goal of a cleaner and greener future.

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REFERENCES

[1]. S. Kumar et al., “Hybrid Solar and Wind Energy Generation System for Highway Applications,” IEEE Access, 2020.
[2]. R. Nithya et al., “Design and Simulation of Vertical Axis Wind Turbine for Low Wind Speed Conditions,” IJSER, 2019.
[3]. A. Patil, “Arduino-based Solar Street Lighting System,” IRJET, Vol 7, Issue 2, 2020.
[4]. P. Sharma, “Hybrid Renewable Energy Systems for EV Charging,” IJERT, 2021.
[5]. S. Verma, “Wireless Charging of Electric Vehicles Using Inductive Coupling,” International Journal of Advanced Research, 2020.
[6]. J. Mathew et al., “Optimization of Battery Usage in Hybrid Energy Systems,” IJRASET, 2022.
[7]. M. Singh, “Smart Poles Powered by Solar and Wind with IoT Applications,” IJETT, 2021.