

Design and development of an energy harvesting unit: A smart energy harvesting unit for highways in Sri Lanka

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The global shift toward renewable energy has intensified interest in wind energy, particularly in capturing airflow generated by passing vehicles on highways. The expressway traffic in Sri Lanka is highly responsive, with constant traffic density, and incorporating Vertical Axis Wind Turbines (VAWTs) for power generation is possible. This research proposes and implements an intelligent energy harvesting system tailored for Sri Lankan highways. The methodology included wind data acquisition along highways, conceptual design of VAWTs, material selection, and incorporation of 36-pole permanent magnet generator for efficiency of power conversion at low speed with direct drive technology, eliminating the need for a gearbox, minimizing friction losses. A 10 W solar cell was incorporated to supplement energy generation. To enhance system performance and data acquisition, ESP32 microcontrollers and an IoT-based real-time monitoring dashboard were developed. Simulation and performance analysis were conducted using MATLAB/Simulink to evaluate the generator's RPM versus voltage, current, and power output. Experimental results showed that the optimized two-blade helical VAWT with a 110-degree twist angle generated consistent power at average wind speeds of 6.3 m/s. At 60 RPM, the system produced 21.2 W of power, with a corresponding current of 1.35 A and voltage of 15.7 V. The system demonstrated low maintenance requirements and high feasibility for implementation, making it a viable solution for Sri Lanka's renewable energy initiatives. The real-time dashboard enables continuous performance monitoring and data logging. These findings support the integration of wind energy systems along highways into national energy strategies, contributing to reduced fossil fuel dependency and the advancement of sustainable infrastructure.

Keywords: *Vertical axis wind turbine (VAWT), Renewable energy, Energy harvesting, IoT*