Hybrid Power Integration on Highways

Mr. D. Abhilash[1], Ms. N. Pravalika[2], Mr. S. Nagaraju[3], Mr. S. Poornachander Rao[4], Mr. P. Rajendar[5]
[1,2,3]*Student, Department of Electrical and Electronics Engineering, Geethanjali College of Engineering and Technology*
[4,5]*Assistant Professor, Department of Electrical and Electronics Engineering, Geethanjali College of Engineering and Technology*

Abstract-The project is the innovative integration of two renewable resources as well as the combination of smart speed breaker helps in effective power generation. The combination harnesses kinetic energy from vehicular movement by Smart Speed breaker, Vertical Axis Wind Turbines and solar energy for solar power generation. Highways witness significant loss in the available forms there is a concern given the limited resources and increasing population. Generated power using these sources can be used for toll gates, street lights and electric vehicle charg

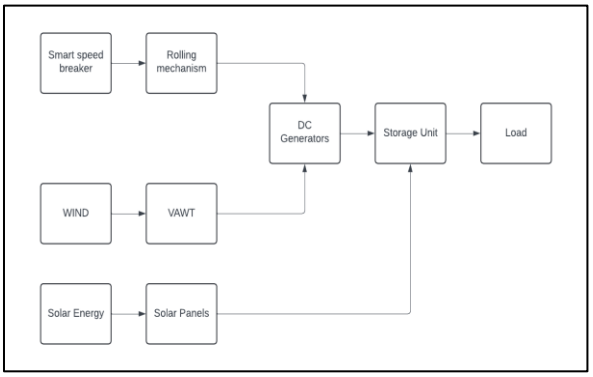
***Index Terms*—DC Generator, Renewable energy, VAWT, Inverter, Rolling mechanism, Solar Panels**

I. INTRODUCTION

The increasing global population presents ongoing challenges in energy distribution and generation, highlighting the need to transition from conventional to non-conventional energy sources. While fossil fuels remain dominant, there is a pressing need to adopt green energy to reduce environmental impact and ensure fair electricity access. Despite advancements, non-conventional methods have yet to fully replace conventional ones. Vertical Axis Wind Turbine (VAWT) situated near highways captures wind force from passing vehicles, converting it into energy. Solar panels further contribute by converting solar energy into electricity, forming a renewable energy source. Rolling mechanism acts as a smart speed breaker which is inclined to the road rotates with the movement of vehicles and generate power with the help of DC generator and stored in batteries.

II. BLOCK DIAGRAM

The block diagram consists of three different sources Vertical axis wind turbine, Smart speed breaker, Solar panels. The power thus generated using these sources is stored in storage unit in daytime and can be used whenever necessary. The main components are DC generator, batteries.



1.Deployment of Vertical Axis Wind Turbines (VAWTs): Install VAWTs in appropriate locations like open fields, coastal areas, or urban regions with consistent wind flow.

2.Solar Energy Utilization: Install high-efficiency photovoltaic (PV) panels either in open areas or on dedicated solar farms. Use tracking systems to maximize sunlight exposure throughout the day. Incorporate solar inverters and energy storage systems such as batteries or grid-connected setups to effectively manage and store solar electricity.

3. Harvesting Kinetic Energy with Smart Speed Breakers: Implement smart speed breakers equipped with electromagnetic systems (DC generator) beneath road surfaces to capture kinetic energy from passing vehicles.

4. Integration of Power Generation Systems: Connect solar panels, VAWTs, and smart speed breakers to power converters and energy storage systems for either grid integration or local power distribution. Employ power electronics such as inverters, converters, and controllers to synchronize energy outputs from these renewable sources.

III POWER GENERATION SOURCES

A) SMART SPEED BREAKER

when the vehicle will come on the speed breaker, electricity produced by a dc generator because it gets rotated linearly with the speed breaker due to coupling of speed breaker with motor shaft. This D.C. voltage is stored to the lead 12- volt battery. The complete arrangement is kept inside the floor level except the speed brake arrangement. Here we are making speed breaker, when a vehicle crosses the speed breaker the speed breaker will rotate on the basisof weight and the speed of the vehicle.

B) VERTICAL AXIS WIND TURBINE

The Wind is caused by the uneven heating of the atmosphere by the sun, variationsin the earth's surface, and rotation of the earth. Wind turbines convert the energy in the wind to electricity by rotating propeller-like blades around a rotor. The rotor turns the drive shaft, which turns an electric generator. Three key factors affect the amount of energy a turbine can harness from the wind are wind speed, air density and swept the area.

C) SOLAR POWER GENERATION

Solar panels are installed on top of structures alongside the highway or on overhead canopies. These panels capture sunlight and convert it directly into electricity through the photovoltaic effect. The generated electricity is then fed into the grid or stored in batteries for later use.

IV. MAIN HARDWARE COMPONENTS

A. Rolling Mechanism

When vehicles traverse over the roller, it sets off its rotation, activating a dynamo linked to a rotor shaft for power generation. This mechanism converts the vertical translational motion of the speed breaker into rotational motion via the connection between the speed breaker and crankshaft.

B. DC Generator

A DC generator converts mechanical energy into electrical energy through electromagnetic induction. It consists of a rotating armature coil within a magnetic field created by stationary field magnets. As the armature rotates, it cuts through magnetic lines of force, inducing an electromotive force (EMF) in the coil.

C. Batteries

They are electrochemical devices that store and supply electrical energy. They consist of one or more electrochemical cells, each containing two electrodes: an anode and a cathode. These electrodes are immersed in an electrolyte solution that facilitates the movement of ions between them. During discharge, chemical reactions occur at the electrodes, producing a flow of electrons through an external circuit, generating electricity. Rechargeable batteries can undergo a reversible reaction when connected to an external power source.

D. Vertical Axis Wind Turbine (VAWT)

A Vertical Axis Wind Turbine (VAWT) is a type of wind turbine where the main rotor shaft runs vertically. Blades are mounted on the rotor shaft perpendicular to the ground, resembling an eggbeater. VAWTs can capture wind from any direction without the need for a yaw mechanism. They are generally compact and suitable for urban and suburban areas. VAWTs are less affected by turbulent winds.

E. Solar panels

A solar panel is a device that converts sunlight into electricity by using photovoltaic (PV) cells. PV cells are made of materials that produce excited electrons when exposed to light. The electrons flow through a circuit and produce direct current (DC) electricity, which can be used to power various devices or be stored in batteries. Solar panels are also known as solar cell panels, solar electric panels, or PV modules.Solar panels are usually arranged in groups called arrays or systems. A photovoltaic system consists of one or more solar panels, an inverter that converts DC electricity to alternating current (AC) electricity.

F. LED

This phenomenon is generally called electroluminescence, which can be defined as the emission of light from a semiconductor under the influence of an electric field. The charge carriers recombine in a forward-biased P-N junction as the electrons cross from the N-region and recombine with the holes existing in the P-region. LED, or Light Emitting Diode, is a semiconductor device that emits light when an electric current passes through it. LEDs are energy-efficient.

G. Inverter

A device that converts direct current to alternating current is called a DC-AC inverter. In general, a circuit

that converts a specified frequency and voltage by combiningan AC-DC converter and a DC-AC inverter, is called an inverter circuit (inverter). The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source.

IV. WORKING

Solar, Smart speed braker system and wind hybrid power systems are designed using solar panels and small wind turbine generators for generating electricity. Generally, solar wind hybrid systems possess small capacitySolar power system includes solar panels, solar photovoltaic cells, and batteries for storing the converted energy .In this project we using solar panel, generator, battery, inverter are assembled for the production of energy by natural mean. In this project we discuss the working, when the wind pass through the turbine blades, turbine will rotate and thus kinetic energy is generated by these rotations which can be converted to electrical energy, which is coupled with generator.Solar panels actually comprise many, smaller units called photovoltaic cells. Which energy is also stored in battery and then this de energy is converted to ac energy by inverter .Smart speed breaker is used for converting kinetic energy of vehicles into electric energy with the help of generator coupled to a gear box.

V. RESULTS AND DISCUSSION

Generation of electricity through the conversion of kinetic energy from passing vehicles. Continuous power generation as vehicles traverse the speed breakers. Integration with the electrical grid or local power systems for distribution and utilization. Conversion of sunlight into electricity and wind energy, offering a reliable and renewable energy source.

Case 1:Power generation during vehicle movement with respect to smart speed breaker:

The power generation process begins when a vehicle engages with the rolling mechanism, illustrated in Figure, utilizing a DC generator. The amount of power generated hinges on both the velocity and weight of the vehicle traversing the highway. This rolling mechanism does not impede the vehicle's speed significantly due to the diminutive height of the speed breaker and the minimal contact area. The interaction point's small size ensures that the vehicle's momentum remains largely unaffected. The vehicle generates energy by the means of kinetic energy.

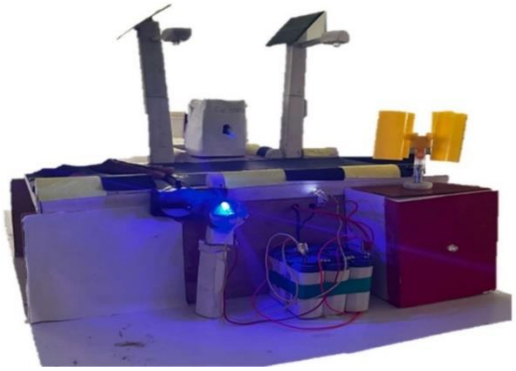


Figure 1: Case 1

Case 2:Power generation using smart speed breaker:

When the vehicle is moved through the speed breaker, due to the energy generated by the DC generator the LED light glows. When the vehicles pass by the road the rolling mechanism is pressed and thus energy is generated. Smart speed breaker power generation involves utilizing the kinetic energy generated by vehicles passing over speed breakers to generate electricity.

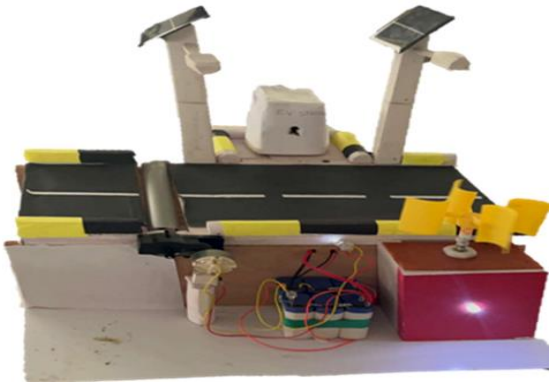


Figure 2: Case 2

Case 3:Power generation using solar panels:

Solar power generation involves converting sunlight into electricity using photovoltaic (PV) panels mounted on street lights, ground-mounted structures. Thesepanels are made up of semiconductor materials like silicon, which generate electricity when exposed to sunlight by exciting electrons in the material. The generated electricity, initially in direct current (DC) form.

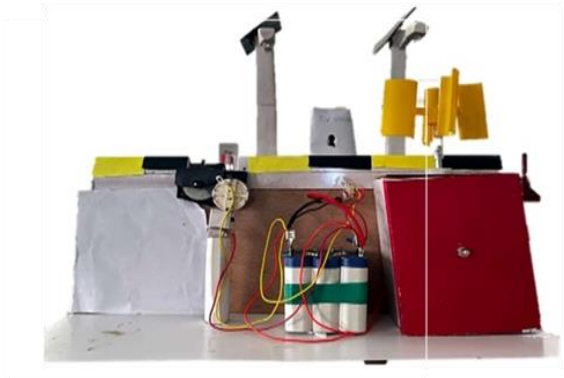


Figure 3: Case 3

APPLICATIONS

1. Smart Highway Lighting: Utilizing the generated electricity to power smart LED lighting systems along highways, improving visibility and safety for motorists while reducing energy costs.
2. Electric Vehicle Charging Stations: Setting up charging stations powered by the integrated renewable energy sources to facilitate the adoption of electric vehicles (EVs) and promote sustainable transportation.
3. Roadside Facilities: Powering roadside facilities such as rest areas, emergency call boxes, and information displays, enhancing convenience and safety for travelers.
4. Traffic Management Systems: Powering traffic monitoring cameras, sensors, and signage systems to improve traffic flow and safety on highways.
5. Grid Connectivity: Integrating the generated renewable energy into the existing power grid, supplementing conventional energy sources and enhancing grid resilience.
6. Off-Grid Applications: Providing electricity to remote or off-grid areas adjacent to highways, supporting local communities with reliable power supply for essential services and economic activities.

VI. CONCLUSION

In conclusion, the utilization of kinetic energy from passing vehicles through smart speed breakers, alongside solar power generation, offers efficient and sustainable means of electricity production. These methods not only tap into renewable energy sources but also enhance road safety and minimize environmental impact. Seamlessly integrating with existing infrastructure, they pave the way for a resilient and eco-conscious energy future. Through continued innovation and implementation, these approaches can play a pivotal role in reducing reliance on non-renewable resources and fostering a more sustainable society.

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