IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Sustainable Energy And Carbon Reduction Through Wind Power

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Abstract: This project explores the integration of a vertical axis wind turbine (VAWT) with a carbon capture system to promote sustainability in energy generation and air purification. The VAWT produces 2-3V of electricity, which is stored in a 9V battery and used to power an LED streetlight. The circuit is designed with a PCB incorporating a 555 timer IC, resistors, diodes, LEDs, and an LDR sensor for automatic activation based on ambient light levels. The carbon capture system absorbs CO2, presenting an innovative method to curb emissions while utilizing renewable energy sources.

Keywords: Wind Energy, Carbon Capture, Sustainable Power, PCB, 555 Timer IC, LDR Sensor.

I. INTRODUCTION

With the increasing concerns over environmental degradation and rising carbon emissions, renewable energy solutions have gained prominence. The consumption of fossil fuels remains a significant contributor to climate change, highlighting the need for cleaner energy alternatives. Wind energy, a sustainable and abundant resource, presents an effective means to generate electricity while reducing environmental impact. This project integrates a Vertical Axis Wind Turbine (VAWT) system with a Carbon Capture System to address two key environmental challenges: sustainable energy generation and carbon emissions reduction. The wind turbine harnesses wind power to produce electricity, which is stored and utilized to operate a streetlight. A light-dependent resistor (LDR) sensor ensures efficient energy use by activating the LED only when ambient light levels drop. Simultaneously, the carbon capture system is designed to filter and absorb CO2 from vehicular emissions, demonstrating an innovative approach to air purification. This system employs IR sensors, a suction mechanism powered by dynamo motors, and a dual-filtration setup to absorb pollutants effectively. By integrating these two technologies, this project contributes to sustainable urban infrastructure while promoting cleaner air.

1.1 Concept

The concept of this project revolves around the dual implementation of renewable energy harvesting and carbon capture technology. The VAWT converts wind energy into electrical power, which is stored and used efficiently for lighting applications. The LDR sensor optimizes energy consumption by activating the LED streetlight only under low-light conditions. The carbon capture system is activated by IR sensors that detect the movement of vehicles. When triggered, a relay module switches on the dynamo motors, creating suction to capture air pollutants. The captured air undergoes two-stage filtration, removing CO2 and other impurities before releasing purified air back into the environment. By combining renewable energy with air purification technology, this project provides a sustainable and eco-friendly solution to energy production and air quality improvement. The system ensures efficient power utilization while actively reducing carbon footprints in urban settings.

II. METHODOLOGY

The methodology follows a structured approach, ensuring that both the VAWT system and carbon capture system function efficiently as a unified model. The project involves two core sections:

1. Wind Energy Generation: The Vertical Axis Wind Turbine (VAWT) rotates using wind force, driving a dynamo motor that produces electrical energy. The generated power is stored in a 9V battery and regulated using a PCB-based circuit. The LED streetlight, controlled by an LDR sensor, automatically turns on in low-light conditions. A 555 Timer IC ensures the stable operation of the lighting circuit.
2. Carbon Capture Mechanism: The system is equipped with IR sensors to detect moving vehicles. When a vehicle is detected, the relay module activates the dynamo motors, creating suction to draw in carbon-laden air. The dual-filtration system separates pollutants, with the first filter removing particulate matter and the second filter absorbing CO2. The cleaned air is then released, significantly improving air quality.

The integration of these two components ensures a self-sustaining, energy-efficient system that contributes to both power generation and environmental preservation. The PCB layout provides a compact and structured design, ensuring optimal energy flow and operational stability.

The Vertical Axis Wind Turbine (VAWT) captures wind energy and converts it into electrical power through a dynamo motor. The generated low-voltage output (2-3V) is rectified and stabilized using a rectifier circuit to ensure a smooth DC output before being stored in a 9V rechargeable battery. A 555 Timer IC manages power distribution to optimize the stored energy.

An LDR (Light Dependent Resistor) sensor plays a crucial role in automating the system. When ambient light levels drop below a certain threshold, the LED streetlight is activated, utilizing the stored energy from the battery. This ensures that the system efficiently conserves energy during daylight hours and

automatically illuminates areas at night, improving urban lighting sustainability. (Figure 1 illustrates this process.)

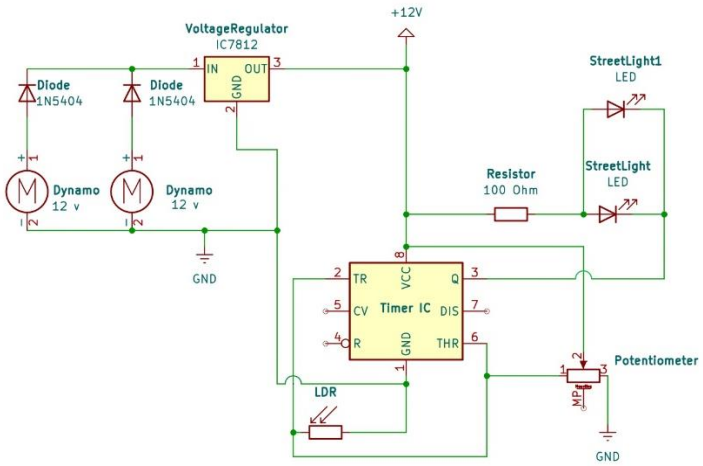

Figure 1: Wind Turbine Energy System

- The vertical axis wind turbine is designed to capture wind energy from multiple directions, maximizing efficiency and power output.
- The dynamo motor converts mechanical wind energy into electrical energy, which is then processed through a rectifier circuit to prevent reverse current flow and ensure safe energy storage in the 9V battery.
- The 555 Timer IC circuit helps regulate power flow, optimizing energy consumption and preventing excess power loss.
- The LDR sensor detects changes in natural light intensity, automatically activating the LED streetlight in low-light conditions. This feature makes the system highly efficient and automated for street lighting applications.

Carbon Capture Mechanism

In parallel, the Carbon Capture System ensures air purification by detecting vehicular emissions and filtering pollutants. The system integrates IR sensors, which identify moving vehicles and subsequently trigger a relay module. This, in turn, activates dynamo-powered suction motors, creating an air intake effect that captures polluted air for filtration. The air filtration system consists of two primary filtration stages, ensuring effective removal of both solid particles and gaseous pollutants. (Figure 2 illustrates this mechanism.)

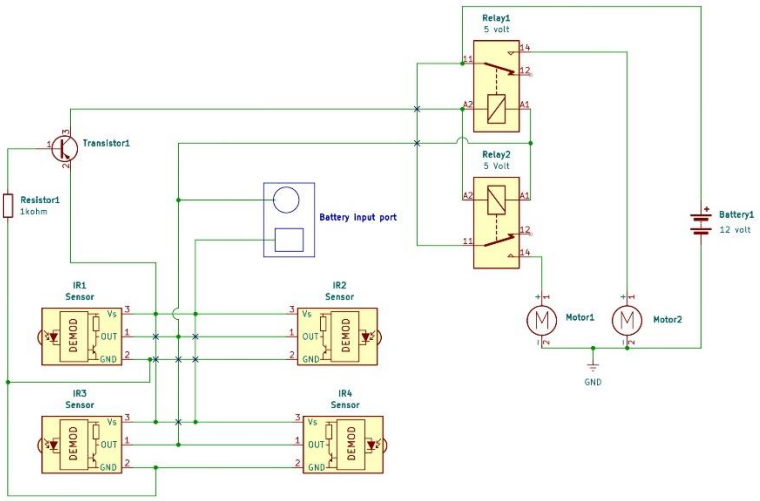

Figure 2: Carbon Capture System

- IR sensors identify the presence of moving vehicles and activate the system only when necessary, thereby conserving energy and increasing operational efficiency.
- The relay module triggers the dynamo motor-powered suction system, ensuring the intake of surrounding air containing CO2, dust particles, and other pollutants.
- The dual-stage filtration unit operates as follows:
    1. Primary filter – Captures solid particulate matter such as dust, soot, and other airborne particles.
    2. Secondary filter – Designed to absorb gaseous pollutants, particularly CO2 and other harmful emissions released by vehicles.
- Once the air is purified, it is released back into the environment, significantly improving air quality in high-traffic areas.

Integrated System Efficiency

The combined functionality of both subsystems ensures an energy-efficient and automated approach to environmental sustainability. The stored wind energy from the VAWT system can also be redirected to power the carbon capture unit, creating a self-sustaining model. This integration provides a dual benefit by addressing both energy shortages and urban air pollution. The system operates autonomously, activating only when needed, reducing unnecessary energy consumption, and promoting environmentally responsible solutions for urban areas.

III. Block Diagram Explanation

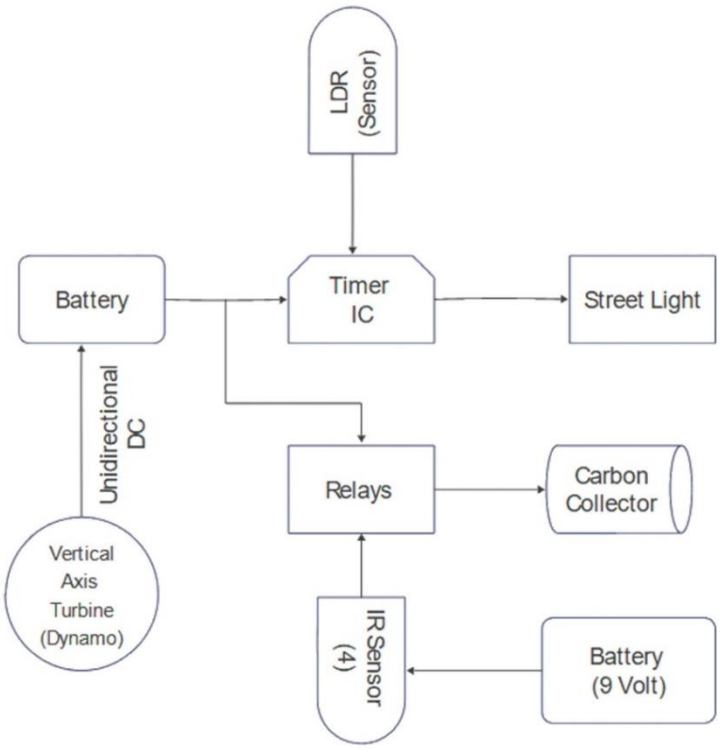

Figure 3: Combine Block diagram of vertical axis wind turbine & carbon capture

The block diagram illustrates the functional integration of the Vertical Axis Wind Turbine (VAWT) System and the Carbon Capture System, highlighting their individual components and interconnections. The VAWT is responsible for harnessing wind energy and converting it into electrical power through a dynamo motor. This generated power is then stored in a 9V battery, ensuring a continuous energy supply even during periods of low wind activity. To optimize energy use, an LDR (Light Dependent Resistor) sensor is implemented, which detects ambient light levels and automatically switches the LED streetlight on or off based on the surrounding brightness. Additionally, a 555 Timer IC regulates power flow, ensuring stable and efficient energy distribution. Simultaneously, the Carbon Capture System operates through an automated mechanism that activates only when vehicle movement is detected. The system employs IR sensors to monitor passing vehicles, triggering a relay module that powers dynamo motor-driven suction fans. These fans create an airflow that draws in polluted air, which is subsequently passed through a dual-stage filtration system. The primary filter removes solid particulate matter such as dust and soot, while the secondary filter absorbs harmful gaseous pollutants, primarily CO_2. The purified air is then released back into the environment, significantly improving air quality in urban areas.

The relay control circuit plays a crucial role in managing the activation and deactivation of the suction mechanism based on real-time vehicle detection, ensuring that the system operates only when necessary. This automation prevents excessive energy consumption, making the system more sustainable. Additionally, the energy generated by the VAWT can also be directed to power the carbon capture unit, ensuring that the entire system remains self-sufficient and operates with minimal reliance on external power sources.By integrating wind energy generation and air purification, this project offers a dual-benefit

solution that not only produces renewable energy but also actively reduces vehicular carbon emissions. The block diagram serves as a comprehensive visual representation of this smart, self-sustaining system, ensuring efficient power management and environmental benefits. Future improvements can incorporate IoT-based monitoring systems and higher-efficiency filtration techniques to further enhance performance and real-world applicability.

IV. RESULTS AND DISCUSSION

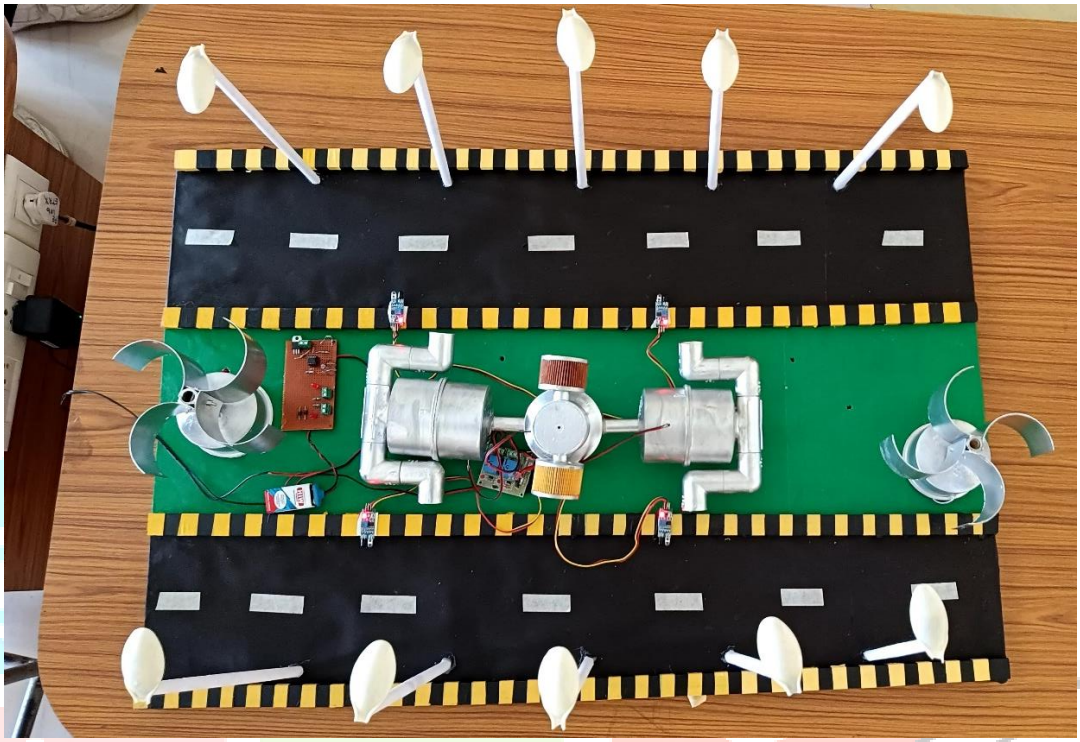

Figure 4: Sustainable Energy and Carbon Reduction through Wind Power

The testing and implementation of this project have yielded positive results in power generation, automation, and air purification efficiency. The VAWT system successfully generates a stable voltage output between 2V and 3V, which is stored in a 9V rechargeable battery and used to power the LED streetlight. The LDR sensor ensures energy efficiency by automatically controlling the light based on surrounding brightness levels. The 555 Timer IC circuit stabilizes the power output, preventing energy wastage. The carbon capture system functions effectively by detecting vehicle movement through IR sensors. The activation of dynamo motors generates suction, pulling in polluted air that is processed through two-stage filtration. This method significantly reduces CO2 emissions and particulate pollutants, making the surrounding air cleaner. The relay modules ensure precise control, operating the suction mechanism only when required, thus minimizing energy consumption. Observations from the prototype indicate that dual-filtration increases efficiency, capturing higher levels of carbon and pollutants compared to single-stage filtration. The use of wind energy to power the system ensures minimal reliance on external power sources, making the model self-sustaining. The compact PCB layout contributes to efficient circuit operation and reduced power losses.

V. CONCLUSION

The integration of a Vertical Axis Wind Turbine (VAWT) System with a Carbon Capture System presents a promising approach to renewable energy generation and air purification. The VAWT efficiently converts wind energy into electricity, storing it for powering an automated LED streetlight system. Meanwhile, the carbon capture mechanism effectively absorbs CO2 and pollutants from vehicle emissions, improving air quality. The energy-efficient design, coupled with smart automation through LDR sensors and relay modules, ensures minimal power wastage. The successful prototype demonstrates the feasibility of integrating clean energy with pollution control technologies, offering a sustainable solution for modern urban challenges. Future enhancements, such as IoT-based monitoring, advanced filtration techniques, and higher-capacity energy storage, could further refine the system's efficiency and real-world applicability.

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