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VERTICAL AXIS WIND TURBINE POWERED HIGHWAY DIVIDER AIR FILTRATION SYSTEM: AN ANALYSIS

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Abstract
The air strikes the vertical axis turbine's blades tangentially, rotating the rotary engine in a single direction. To produce energy, the generator is attached to the vertical axis wind turbine's shaft. A battery is used to store the electrical output of the vertical DIVIDER-BASED axis turbine. This energy has been saved and can be utilized to filter air. The most serious worldwide issues of our day are air quality degradation and global warming's impact on the climate. The amount of air pollution is growing, causing droughts, harsh summer and winter temperatures, changes in seasonal rhythms, an increase in water levels, and heating. Alongside a range of pandemic and endemic illnesses. India's air quality is in terrible shape. Approximately 54% of Indians reside in cities that do not fulfill WHO and NAAQS guidelines for fine particulate matter. The deterioration of air quality that impacts all forms of life material disturbs not only Asia but the entire world. Therefore, the goal is to create a system that can use the energy it produces on its own to manage air pollution.

Keywords:
Air Pollution, HEPA Filter, Vertical Axis Wind Turbine, Renewable energy

Introduction

The demand for electricity in daily life exceeds supply by a large margin. one of the primary problems since natural resources are expected to run out at some point in the future. The fuel plays a significant part in the production of heat, greenhouse gas emissions, etc [1]. As of right now, thermal power plants generate 68% of the electrical energy produced; the other 22% comes from hydropower, nuclear, and gas plants, as well as the realisation that fossil fuels run out quickly. Because of the speed of the car, wind energy is at its highest on highways [2]. This project's motivation supports the worldwide movement towards renewable energy. Managing air pollution is a challenging task as it arises from various sources such as automobile emissions, suspended dust, industrial emissions, burning garbage, residential heating, and cooking [3]. Apart from these, there are other seasonal causes such as the burning of agricultural waste, sandstorms or dust storms, and sea salts. Climate change and global warming are caused by air pollution.

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One of the greatest worldwide issues facing humanity is climate change, which has drawn significant attention from scientists and the media worldwide [4].

The battery is a collection of cells used as a storage unit. It generates electric power through a chemical process that results in the production of chemical energy, which is then transformed into electric energy and used to power the vehicle's electric components [5]. There are numerous battery types that are used to generate power for different purposes, including lead acid, nickel cadmium (NiCd), nickel-metal hydroxide (NiMH), lithium-ion, and lithium polymer batteries. Lead acid batteries are the most widely used battery type in vehicles with internal combustion engines (ICs) [6]. In contrast, big-sized lithium-ion and lithium polymer batteries are employed in EVs to match their need for a huge power source. These batteries' primary functioning parts are the positive and negative electrodes, as well as an electrolyte that can be either a solution or a solid. Additional parts include the container, connecting wire harness, separators, terminals, and caps [7]. Lead oxide paste covers a plate that serves as the positive electrode in lead acid batteries, while lead itself serves as the negative electrode. This battery uses sulfuric acid and water as its electrolyte [8].

Lithium metal oxide serves as the positive electrode, porous carbon serves as the negative electrode, and an organic solvent-containing lithium salt serves as the electrolyte in lithium-ion batteries [9]. Through the use of conducting wires to connect the positive and negative electrodes, electrons will flow from one terminal to the other, producing electricity. The lithium-ion or lithium-polymer battery in an electric vehicle (EV) must continuously supply electricity to allow the vehicle to move forward, but the lead acid battery used in internal combustion (IC) engines will only supply a very small amount of power and will not discharge readily [10]. Because of this, the EVs' batteries will run out very quickly and need to be charged regularly. However, the truth is that electric vehicles' batteries cannot be charged while the car is in motion. Additionally, these batteries will require a longer power source over time [11]. The price of power will directly rise as a result of this. As a result, people will favour conventional internal combustion (IC) engine vehicles over electric vehicles (EVs) for transportation purposes. Therefore, there needs to be a way to allow EV batteries to charge while the car is moving. This would extend the car's driving range without raising the expense of charging the car [13].

The answer in this case is to install a system that permits battery charging while the car is moving, i.e., without stopping to allow for charging. This is accomplished by utilising wind energy, which is the most renewable energy source. A wind stream will enter the front part of the car through the grille as it is moving. There will be variations in the amount of air that enters the vehicle according on its speed. There will be less airflow if the car is moving slowly. There will be more airflow if the car is travelling faster [14]. The electricity needed to charge the EVs' batteries will be produced from this air. The Vertical Axis Wind Turbine, or VAWT, is being used to harness this incoming air. The Vertical Axis Wind Turbine (VAWT) and the Horizontal Axis

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Wind Turbine (HAWT) are the two main types of wind turbines. The primary factor in choosing VAWT was its tiny footprint and its ability to be secured in situ because to its compact structure [15]. In addition, in comparison to the HAWT turbine, the size to power ratio is likewise high. This VAWT turbine will be installed inside the vehicle's front grille, where airflow will enter the car.

Repulsion Savonius Wind Turbine with Vertical Axis

This turbine's simplified design is its standout feature. In the 1920s, Savonius, a Finish engineer, invented the Savonius rotor. When viewed from above, this shape is identified as a "S." These rotor types can be employed in single- or multi-stage configurations and have blade counts of two, three, or more.

Several earlier studies served as the foundation for the blade's and its airfoil's design. Figure 1 displays the Vertical Axis Wind Turbine (VAWT) computer-aided design (CAD).

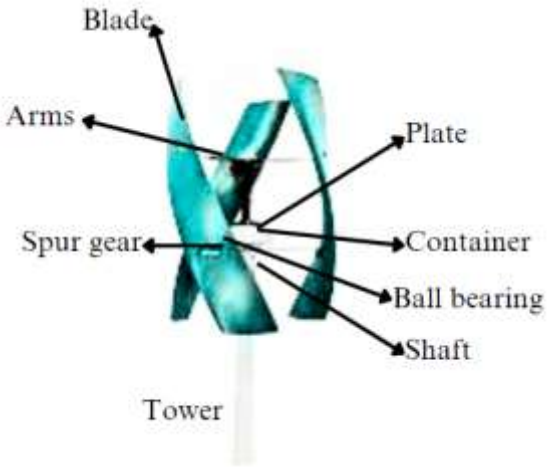

Figure 1 CAD design of the Vertical Axis Wind Turbine with it's main parts

Compared to conventional horizontal-axis wind turbines, vertical-axis wind turbines (Figure 2) have a number of advantages. They create less force on the support structure and are silent and omnidirectional. They can be closer to the bottom in areas with lesser wind speeds because they don't require the strongest wind to generate power. They can be mounted atop chimneys and other similar tall structures and are simpler to maintain because they are closer to the ground.

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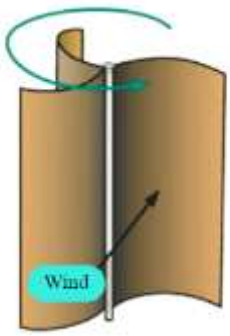

Figure 2: Vertical Axis Wind Turbine

Air Purifier

Originally known as high-efficiency particulate absorbers, high-efficiency particulate arrestors (HEPAs) can be stacked closer together in wind farms, providing more space in a given dwelling. They create less force on the support structure and are silent and omnidirectional. They want to be closer to the bottom, where the wind speed is lower, because they don't want the strongest wind to exert its maximum force. The filter needs to meet efficiency requirements, such as those established by the US Department of Energy (DOE).

What constitutes a HEPA filter is specified by these standards. According to the two most often used standards, an air filter must eliminate 99.95% (European Standard) or 99.97% (ASME standard) of particles larger than or equal to 0.3μm from the air that passes through. Unlike ionic and gas filtration, which uses negative ions and gas many times, HEPA filtration operates mechanically. Thus, the likelihood of developing respiratory adverse effects such as allergies and asthma is significantly reduced when using HEPA purifiers. In business settings, HEPA filters should be inspected and replaced at least every six months to guarantee optimal performance. Figure 3 is the architecture of HEPA air filter.

Figure 3: HEPA Air filter

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Methodology

There are two key components to this project. Energy generation is the initial phase, and using energy that has been harnessed is the second.

A wind turbine with a vertical axis is installed on the dividers that divide the roads. The air turbulence produced by moving cars on roadways powers the turbine. An additional benefit of this project is the availability of air in both directions. Aluminium sheets are used to make the shaft and turbine blades. After that, a DC motor is connected to the turbine. Pulse width modulated DC voltage powers this brushless DC motor, which runs at 12 volts. After that, the battery and motor are connected to store the energy produced. Figure 4 presents the block diagram of wind turbine.

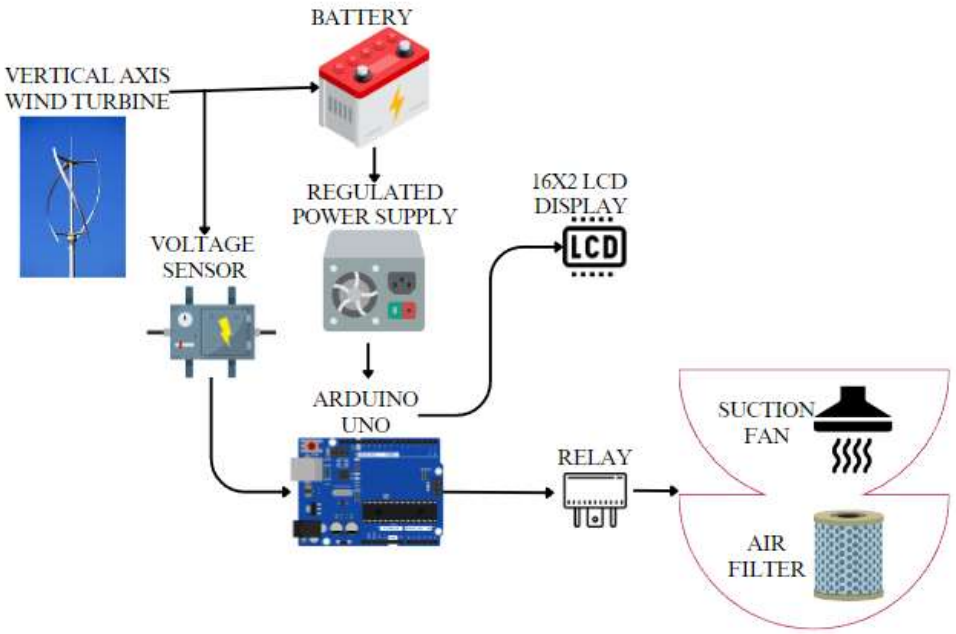

Figure 4: Block Diagram

Display devices are also connected in the interim. It is first linked to a voltage sensor module that gauges the voltage that is produced. An Arduino UNO gadget built around a microcontroller is connected to the voltage sensor's output. The voltage sensor provides input to the Arduino, and transforms the received data. The transformed data is handled such that the LCD display board can see it. Here, a 16x2 liquid crystal display is being used as the display device. Additionally, an RPS (Regulated Power Supply) unit is included with the system. The RPS's primary job is to distribute the battery's energy for the various energy needs of the circuit. The battery's electricity will then be used to remediate the contaminated air. Thus, an air filter is

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the primary part of this procedure. The HEPA (High Efficiency Particulate Arrestor) filter is the best type of air filter for this job. A relatively uncommon type of filter that can filter contaminants with different particle sizes, including nanoparticles, is the HEPA filter. To remove solid particles from the air, a filter paper is coiled around the air filter. The recommended filter in this case is cylinder-shaped, hollow inside, and top-opening.

A fixed exhaust fan is located at the filter's top. The contaminated air is now going through the layers of filter paper and HEPA filters as a result of the exhaust fan sucking the air through the filter. It suggests that the vast majority of air contaminants have been removed. The atmosphere is exposed to the treated air. The battery provides the energy needed to run the exhaust fan. The fan receives its electricity through a relay rather than directly from the source. The relay ensures that only when the wind turbine is rotating is the exhaust fan turned on. It indicates that the exhaust fan is turned off when there are no cars on the road and the turbine is not spinning. This is critical since energy of any kind ought not be squandered.

Results

The turbine began to rotate when air began to strike the turbine blades, creating turbulence in the surrounding air. The turbine uses the most wind energy possible since it has a sufficient number of well-designed turbine blades.

The available mechanical energy is first converted to electrical energy by the motor and turbine. Both the voltage sensor and the battery are connected to the motor's terminals. According to Table 1 fixed distance between the fan and turbine is 0.56 m and the temperature is 34 degrees Celsius. Test 3 shows the highest RPM and voltage compared to the other two tests. Below barchart (figure 5) shows the results of wind speed. Figure 6 demonstrates the result of wind speed taken in the morning.

Table 1 DATA COLLECTION

Distance between fan & turbine = 0.56 m			Temperature = 34 °C	
Test	Cut-in wind speed	Average wind speed (m/s)	Rotations per minute (RPM)	Voltage (V)
Test 1	2	2.1	43	3.17
Test 2	2	3.3	54	4.45
Test 3	2	4.5	65	5.78

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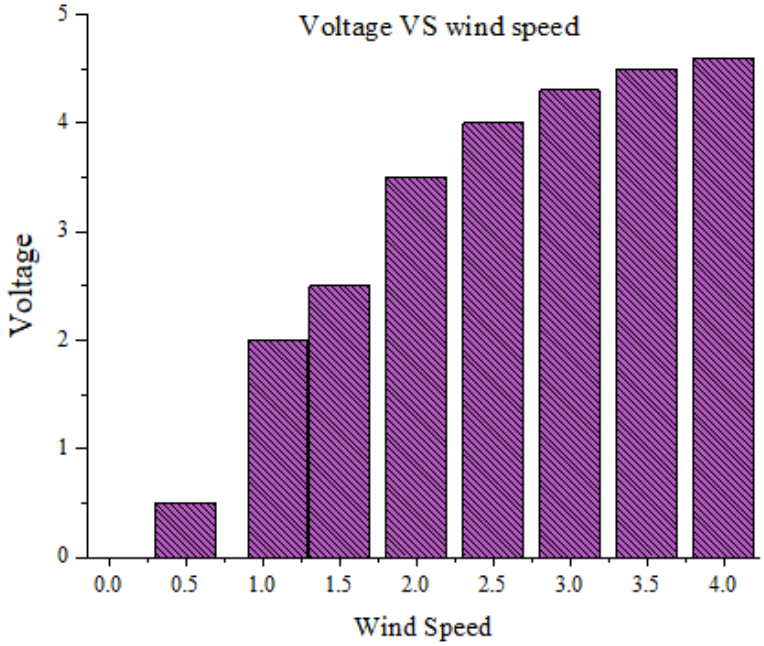

Figure 5 Wind speed (m/s) vs turbine speed (RPM)

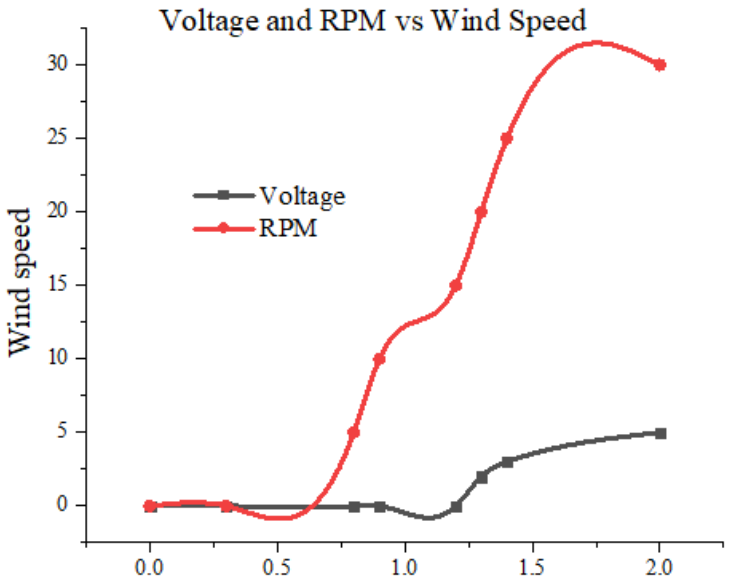

Figure 6 Voltage and RPM vs wind speed (Morning)

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The electrical power in Figure 7 increases roughly linearly with wind speed, suggesting that the wind turbine can produce large amounts of electricity at high wind speeds.

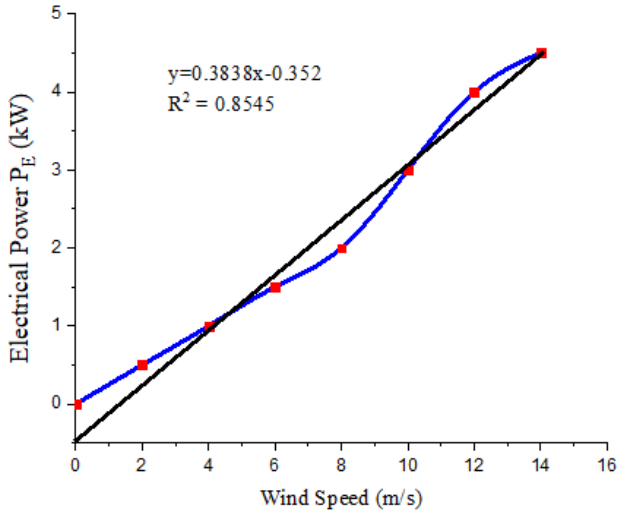

Figure 7 The generated electrical power P E vs wind speed V w.

For the purpose of power conversion, a rectifier circuit connects the terminals to the battery. The Arduino receives signals from the voltage sensor, and the LCD board displays the outcome. When the turbine rotates, or when the battery is charging, the relay in this model, which functions as a switch, is turned on. The relay turns off and there is no supply when the turbine ceases to spin.

The exhaust fan begins to whirl when the supply is turned on. The air is drawn through the filter by it. The greatest amount of contaminants are eliminated from the air when the tainted air is drawn through the filter. As a result, the quality of the air is enhanced.

Future Scope

- The number of automobiles on the road is growing every day, and with it, so does the electricity produced by wind turbines.
- In the upcoming years, air pollution in Indian cities will become a serious issue. Thus, implementing methods such as these at the earliest opportunity will guarantee a better future for cities.
- This approach will always be useful, even if electric vehicle technology undergoes a revolution in the future.
- Since green energy is the theme of the future, we may produce energy using more futuristic methods and put it to use for a variety of uses.

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- When this technology is combined with solar energy generation, a significant amount of power that can be used for various tasks will be produced.
- A different type of air filter with a longer cycle life than current filters could be created with study on the maximal elements of vehicle air pollution.

Conclusion

This system is environmentally friendly. The working model of our project is a vertical axis wind turbine system which is a good and effective solution for power generation, Highway side application of wind turbine with improved efficiency can help us to reduce the gap between demand and supply of power. The designed air filtration system can be used to engulf all air pollutants from the vehicle discharge at all the express highways in India. For this system we don't require any extra power rather we use the power generated by the wind thrust of vehicle movement by use of vertical axis wind turbine. Thereby the design system would help to minimize air pollution at its source without any extra effort.

Abbreviation

WHO- World Health Organization
HEPA – High Efficiency Particular Srrestors
NiCd – Nickel Cadmium
NiMH – Nickel-metal Hydroxide
ICs – Internal Combustion Engines
EV – electric Vehicle
Evs – Electric Vehicles
VAWT – Verticle Axis Wind Turbine
HAWT – Horizontal Axis Wind Turbine
CAD – Computer Aided Design
DOE – Department of Energy
RPM – Rotation Per Minute

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable

Ethics approval and consent to participate

Not applicable

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Availability of data and materials

Not applicable

Authors' contribution

Author A supports to find materials and results part in this manuscript. Author B helps to develop literature part.

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