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A Study on Wind Turbines with Solar Power and Vertical Axis to Power Highways

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Abstract

To meet the need for electricity, renewable energy generation is rapidly expanding. Renewable energy sources include solar and wind. Solar energy is available at the start of the day, and wind energy is at its peak on the highway due to vehicle speed. This paper's rationale helps to the global trend toward renewable energy. The utilisation of air on a highway divider with the help of a vertical axis wind turbine is the subject of this research. Due to its speed, the vehicle passing on the highway produces a significant amount of air. This air impacts the blade of a vertical axis wind turbine tangentially, causing the rotor to rotate in just one direction. The solar system is used to generate electricity and is also designed to direct vehicle exhaust into the turbine. To create energy, the vertical axis wind turbine's shaft is connected to the generator with the gear mechanism. A battery stores the electrical output of the vertical axis turbine and the solar system. This stored energy can be used for street lighting, toll gates, and other applications. The paper shows the hardware implementation of a vertical axis wind turbine (VAWT) with a solar panel.

Keywords: *Renewable energy, Electricity, Power generation, VAWT, Solar panel*

INTRODUCTION

Renewable energy is currently the most important topic in the world. It was discovered that the world's fossil fuel reserves are fast depleting, and no new reserves have been discovered. Furthermore, energy production from fossil fuels has the potential to generate a slew of environmental issues, including greenhouse gas emissions, global warming, and acid rain. In these types of situations, renewable energy sources are critical. Renewable energy comes from renewable sources including wind, sunlight, rain, tides, waves, geothermal heat, and so on. Renewable energy is typically used to power four different regions. Electricity generating, air and water heating and cooling, transportation, and rural (off-grid) energy services are the four categories. Iceland and Norway, for example, already use renewable energy to create electricity. Many countries have set a target of achieving 100% renewable energy in the future. Denmark's government, for example, has pledged to move to 100 percent renewable energy for total energy supply (electricity, mobility, and heating/cooling) by 2050. The primary goal of this article is to harness as much wind energy as possible from automobiles travelling down motorways. The unused and significant amount of wind is used to power the vertical axis wind turbine, which will generate electricity using the kinetic energy of the wind. The energy generated by the VAWT and solar system is stored in a battery and can be utilised for street lights, toll gates, or, in the future, to provide a charging station for electric vehicles.The wind forces generated by moving vehicles are becoming increasingly meaningless, necessitating the development of a device for generating electricity from wind generated by moving automobiles. The difficulty arises in calculating the exact number of blades for a wind turbine, which is corrected by wind speed and voltage.

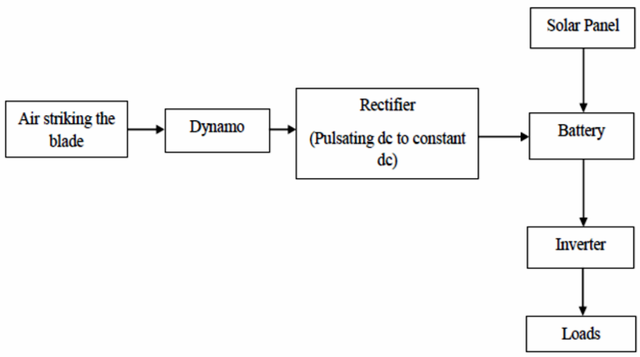

Fig1: Block diagram representing the working of VAWT and Solar panel for power generation.

Figure 1 shows the operation of a vertical axis wind turbine and a solar panel. It includes a vertical axis wind turbine, a dynamo, a rectifier, a solar panel, and an inverter. Because of the vehicle's speed, some pressured air is produced whenever it moves on both sides of the highway. The turbine's blades are rotated by the compressed air striking them.

The turbine's shaft is connected to the generator. The generator produces an alternate quantity of power. The rectifier rectifies the generator's output and stores it in the battery. The turbine has a solar panel installed atop it. Solar electricity is direct current (dc) and is stored in a battery. The stored energy is converted to ac and used for lights and other household purposes.

2. ANALYSIS OF WIND TURBINE AND SOLAR PANEL

A wind turbine is a machine that converts wind kinetic energy into electricity. The rotor of a wind turbine is made up of a series of blades coupled to a rotor hub; the rotor deflects the airflow, creating a force on the blades, which in turn produces a torque on the shaft, which is primarily connected to a gearbox and generator. The horizontal axis wind turbine (HAWT) and the vertical axis wind turbine (VAWT) are the two main types of wind turbines (VAWT). The goal of one type is to generate power from wind at high speeds. The other variety, on the other hand, is designed for places with low wind speeds.

Types of On-shore wind turbines

Horizontal axis wind turbine The horizontal wind turbine is one in which the rotor's rotation axis is parallel to both the wind and the earth. The majority of modern HAWTs have two or three blades, while some may have fewer or more. The upwind wind turbine and the downwind wind turbine are the two types of Horizontal Axis Wind Turbines.

Vertical axis wind turbines: They are closer to the ground, making them perfect for catching low-speed wind in residential and urban environments. The blades can capture wind blowing from any direction because the rotor revolves on a vertical axis, and so create power without the requirement of a yaw mechanism. The turbine produces less energy and produces less noise, making it ideal for residential homes looking to reduce their carbon footprint. They require less maintenance than horizontal axis wind turbines, making them excellent for households and business owners.

Darrieus wind turbines move their blades along a vertical axis using the airfoil idea described above. This enables the Darrieus turbine to rotate at nearly any speed.

One of the most basic turbines is the Savonius turbine. In terms of aerodynamics, it's a drag device with two or three scoops. A two-scoop machine would appear to have a "S" form in cross section when viewed from above. When travelling against the wind, the scoops incur less drag than when going with the wind due to the curvature.

The Savonius turbine spins due to the differential drag. Savonius turbines extract substantially less wind power than similar-sized lift-type turbines since they are drag-type devices. Because of the lower wind speeds observed at lower heights, much of the swept surface of a Savonius rotor may be near the ground if it has a tiny mount without an extended post, making overall energy extraction less effective.

Because the rotor is mostly propelled by drag, its top speed is equal to that of the wind. Because models can be created from items obtainable in local hardware stores, this form of wind turbine allows for an inexpensive and simple do-it-yourself home project.

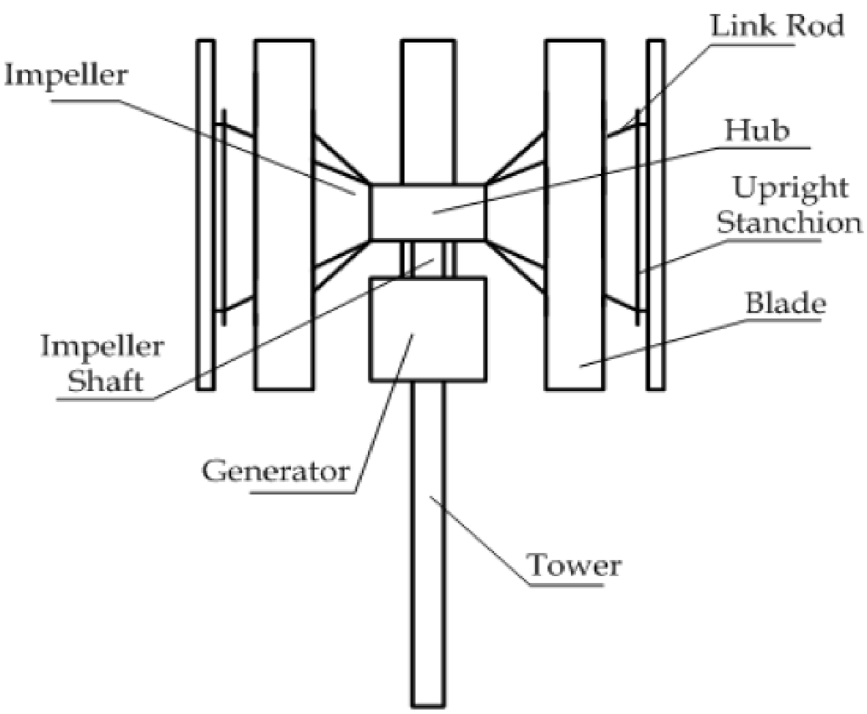

Fig 2: Savonius wind turbine

Off-shore wind turbines

The rotors of offshore wind turbines are substantially larger than those of onshore horizontal-axis wind turbines. Because there are less barriers such as buildings and hills offshore, the wind blows more faster and more laminar than onshore, hence offshore wind turbines do not need to be as tall as onshore wind turbines. As a result of the higher wind speeds, it is clear that even a small increase in wind velocity can result in a considerable increase in power generation for offshore wind turbines.

The majority of offshore wind turbines are placed in shallow water, usually less than 30 metres deep. Before piles may be driven 24 to 30 metres into the seabed, an environmental impact assessment must be completed. More offshore wind turbines have recently started relocating to transitional water, which is between 30 and 60 metres deep. Simple piles will not be enough to keep these wind turbines from swaying in the wind, thus tripod-like platforms or wider-base constructions will be required.

DESIGN AND CONSTRUCTION

Methodology:

Fabrication: Fabrication of a vertical axis wind turbine (Savonius type) is made up of many pieces that must be produced as part of the main assembly.

The parts of VAWT to be fabricated are as follows:

Base: The base is 50 cm tall and 40 cm wide, with a thickness of 1 inch. The purpose of the base fabrication is to provide a sturdy support for the turbine against high-speed wind. It is meant to decrease turbine vibrations caused by turbulent winds. The rotor is held by the base, which has a fixed shaft perpendicular to the rotor. The power generating unit is likewise housed in the base.

Blades: galvanized Turbine blades are made of steel. The blades are around a millimetre thick. There are eighteen blades, each measuring 60 cm in length and 15 cm in width. Perpendicular to the rotor, these blades are attached.

Shaft: When creating the shaft of a blade, it should be well suited to the blade, with as little thickness and weight as feasible. It is made of hollow aluminium and is extremely light in weight.

Generator: Dynamo is used to produce electricity of 12 volts.

Drive system: The power is sent from the turbine to the generator via a gear system. A 1:6 gear ratio is employed.

Variables:

Wind speed: This is critical to a wind turbine's productivity. The wind turbine uses just the wind to create electricity. The shaft of the generator sweeps over the magnetic coils as the axis (horizontal or vertical) rotates, providing an electric current.

Blade length: This is significant because the swept area is directly proportional to the blade length. With a larger swept surface, larger blades catch more wind with each rotation. They may also have increased torque as a result of this.

Base height: The windmill is greatly influenced by the height of the base. Because wind speeds rise as altitude increases, the taller a windmill is, the more productive it will be.

Base design: Some bases are more powerful than others. The base is critical in the building of a windmill because it must not only support the windmill but also withstand their own weight and the drag of the wind. If these ingredients are applied to a weak tower, it will undoubtedly fall. As a result, the foundation must be identical to ensure a fair comparison.

Tip speed ratio: The tip speed ratio is essential. The productivity of a windmill is directly proportional to its tip speed ratio. It's the number of times the blades spin faster than the wind speed.

Design of a VAWT and solar with specifications:

Table1: Components of VAWT and its specifications

Sl.No	Components	Specifications
1	Height of blade	60 cm
2	Width of blade	15 cm
3	Angle of curvature	150 °
4	Number of blades	17
5	Base height	50 cm
6	Base width	40 cm
7	Gear ratio	1:6

Fig3: Design of VAWT

As illustrated in Fig 3, the turbine blades are 60 cm long and made of galvanised iron, with a height and breadth of 15 cm. The blades are bent at an angle of 150 degrees. The shaft was attached to the blades using an iron rod, and they were all set at a 20-degree angle. The hub is connected to a shaft, which is then paired with a dynamo, whose number is increased to achieve high torque and easy spinning.

Table2: Components of solar panel and its specifications

Sl.No	Parameters	Specifications
1	Rated maxium power (Pmax)	20 W
2	Open circuit voltage (Voc)	21.1 V
3	Short circuit current (Ise)	1.58 A
4	Rated voltage (Vmax)	17 V
5	Rated current (Imax)	1.16 A
6	Maximum power tolerance (%)	5 %

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IMPLEMENTATION

Dynamo: A dynamo is an electrical generator that uses electromagnetism to produce direct current electric power.

Dynamos were the first electrical generators capable of supplying power to industry, and they served as the foundation for many subsequent electric-power conversion devices, such as the electric motor, alternating-current alternator, and rotary converter. For efficiency, reliability, and economic reasons, the simpler alternator now dominates large-scale power generation. See Figure 4

Rectifier: A rectifier is an electrical device that transforms alternating current (AC), which reverses direction on a regular basis, to direct current (DC), which only flows in one direction. The procedure is called correction. Vacuum tube diodes, mercury-arc valves, copper and selenium oxide rectifiers, semiconductor diodes, silicon-controlled rectifiers, and other silicon-based semiconductor switches are all examples of rectifiers. See Figure 5

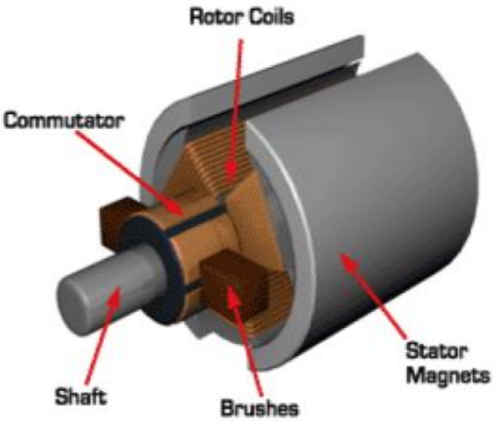

Fig4: Dynamo

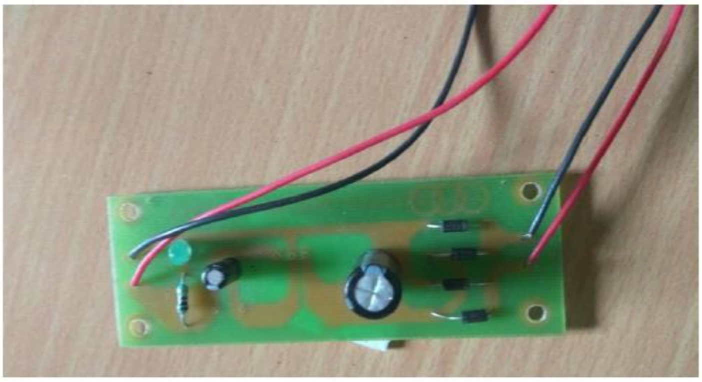

Fig5: Rectifier

Battery: A battery is a self-contained chemical power source that can create a finite amount of electrical energy when needed. A battery converts the chemicals it contains into electrical energy over a period of days, weeks, months, or even years. A cell is the basic power unit inside a battery, and it is made up of three primary bits. A substance termed an electrolyte is sandwiched between two electrodes (electrical terminals). There are two more handy electrical terminals designated with a plus (positive) and minus (negative) on the outside connected to the electrodes that are inside for our convenience and safety. See Figure 6

Inverter: When a 12VDC power supply is provided, this DC to AC inverter provides 220VAC. It can supply very low-power loads like night lamps and cordless phones, but by adding more MOSFETs, it can be upgraded to a strong inverter. The output power is driven by two high-power IRFZ44 MOSFETs, and the 4047 IC serves as a stable multivibrator with a frequency of roughly 50 Hz.

The IC's 10 and 11 pin outputs are utilised to drive power MOSFETs in a push-pull configuration. The output transformer has a 9V-0-9V secondary with 2 Amps and a 230V primary. For MOSFETs, use appropriate heatsinks. See Figure 7

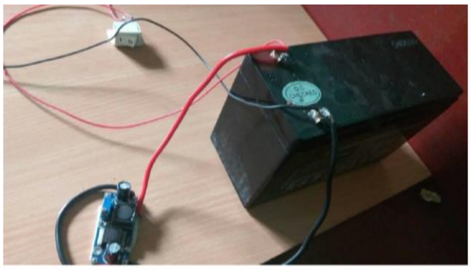

Fig6: Battery

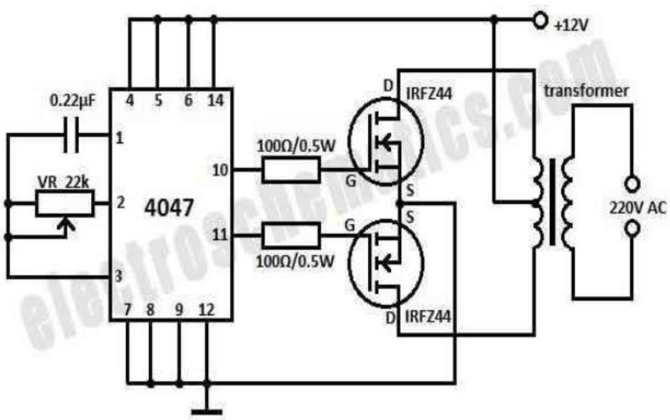

Fig7: Schematic of the DC to AC Inverter Circuit

RESULT ANALYSIS

The test is carried out to determine the effectiveness of the created products. Installing the model near highways is used to test the project's effectiveness. To compare the data, both the output voltage and the rate of revolution are recorded. When there is a lot of wind speed and the turbine is rotating with typical wind flow, the following data are obtained. The output voltage fluctuates between 6.7 and 10.2 volts.

Table 3: Output obtained for different wind speed and time

Time (Min)	Wind speed (m/sec)	Output voltage (Volts)
11:00-11:15	15.25	9.6
11:15-11:30	15.33	9.8
11:30-11:45	15.28	9.6
11:45-12:00	15.25	9.6
12:00-12:15	15.24	9.6
12:15-12:30	15.23	9.7
12:30-12:45	15.32	9.8
12:45-01:00	15.25	9.6
Average wind speed=15.2775 m/sec		

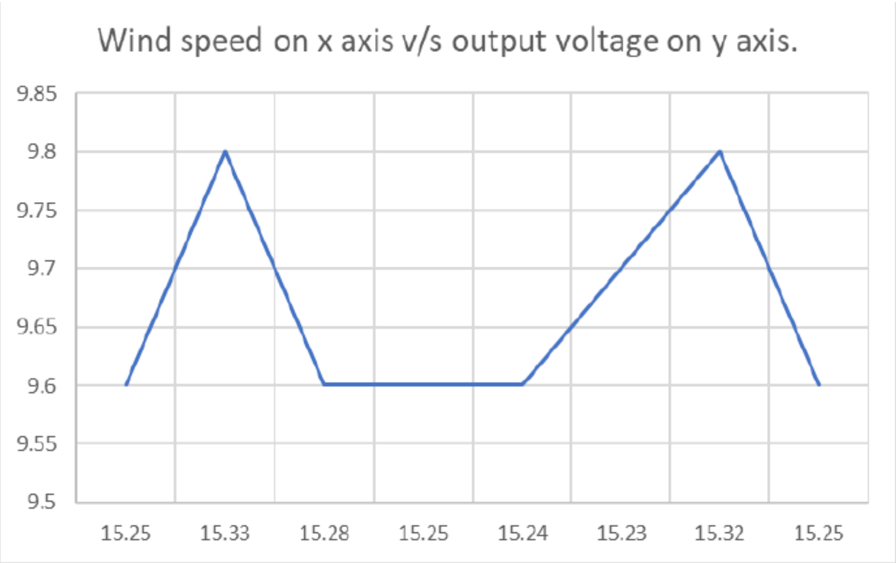

Fig8: Graph of output voltage versus wind speed

Table 4: Output obtained by solar and turbine at intervals of time

Time (min)	Wind turbine voltage V_1(Volts)	Solar panel voltage V_2(Volts)	Ouput voltage V(Volts)
11:00 am-11:15 am	9.6	19.68	29.28
11:15 am-11:30 am	9.7	19.67	29.37
11:30 am-11:45 am	9.7	19.68	28.55
11:45 am-12:00 pm	9.6	18.95	28.55
12:00 pm-12:15 pm	9.6	18.95	28.59
12:15 pm-12:30 pm	9.6	18.99	28.60
12:30 pm-12:45 pm	9.6	19	28.55
12:45 pm-01:00 pm	9.6	18.95	28.60

Fig 8: Whole set-up of VAWT and solar panel

CONCLUSION

Wind is a low-cost, environmentally friendly, renewable energy source. The use of high-efficiency wind turbines on highways can assist close the gap between demand and supply of electricity. The project's functioning model is a combined energy source with solar panels and a vertical axis wind turbine, which is a good and efficient solution for power generation in motorways. And, in essence, this system combines two energy systems; if one source fails to generate, the second source will continue to generate electricity and provide continuous power to the load. The electricity is generated using renewable energy sources such as solar and wind energy.

As a result, energy from moving automobiles on the highway can be transformed into electricity. Change the number of blades and the materials used to further enhance this project. This applies to the entire region, and regional parameters are also taken into consideration for better outcomes. This concept does not require any restrictions or a big amount of space, as nuclear or other forms of power plants do; it can be built anywhere on the planet and produce more electricity. This type of power plant is the most effective means of reducing global warming.

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