International Journal of Engineering Sciences &Research Technology

(A Peer Reviewed Online Journal)
Impact Factor: 5.164

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THOMSON REUTERS

[Somnath * *et al.*, 8(6): June, 2019]
IC™ Value: 3.00

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

POWER GENERATION ON HIGHWAY USING VERTICAL AXIS WIND TURBINE AND SOLAR ENERGY

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DOI: 10.5281/zenodo.3256147

ABSTRACT

The rapid growth of renewable energy generation is increasing to meet the demand for electricity. Solar and wind both are renewable energy sources. Solar energy available begins of day and the wind energy is maximum on the highway due to the speed of the vehicle. The motivation of this paper contributes the global trend toward clean energy. This paper focuses on use of air on highway divider with the help vertical axis wind turbine. When the vehicle passed on the highway it produces a considerable amount of air due to its speed. This air tangentially strikes on the blade of the vertical axis wind turbine and its makes a rotation of the turbine in only one direction. The solar system is used to generate electrical energy and also installed in a way that it diverts the vehicle air towards the turbine. The generator with the gear mechanism is connected to the shaft of the vertical axis wind turbine to generate electricity. The electrical output of vertical axis turbine and the solar system is stored in a battery. This stored energy which can be further used for street lighting, toll gates, etc. Hardware implementation of the vertical axis wind turbine (VAWT) is presented in the paper with solar panel.

KEYWORDS: VAWT, Converters, solar panel.

1. INTRODUCTION

Renewable energy is the most important topic in the world at present. It was identified that the fossil fuel reserves in the world are diminishing rapidly and no reserves were identified. In addition to that, energy generation from fossil fuel may cause so many environmental problems like emission of greenhouse gasses, global warming and acid rains. Renewable energy sources play a major role in these types of situation. Renewable energy is the energy that extracts from renewable sources such as Winds, Sunlight, Rain, Tides, Waves, Geothermal heat…etc. Normally renewable energy provides energy for four different areas. They are electricity generation, air and water heating/cooling, transportation, and rural (off-grid) energy services. As an example, Iceland and Norway already generate their electricity by using renewable energy. A lot of countries have set up a goal to reach 100% renewable energy in the future. For example, the government of Denmark has decided to switch the total energy supply (electricity, mobility and heating/cooling) to 100% renewable energy by 2050.

Objective: The main objective of this paper is to utilize the maximum amount of wind energy from the automobiles running on the highways. The unused and considerable amount of wind is used to drive the vertical axis wind turbine, which will use the kinetic energy of the wind to produce the electrical energy. The generated energy by VAWT and solar system are stored in a battery and this stored energy which can be used street lighting, toll gates or in future to provide the charging node to the electrical vehicle.

Problem statement: The wind forces from moving vehicles is getting useless, therefore, there exists an immense need of a system for generating electricity from wind induced by moving vehicles. The problem rises in designing the exact number of blades for wind turbine which is rectified by the amount of wind speed and voltage.

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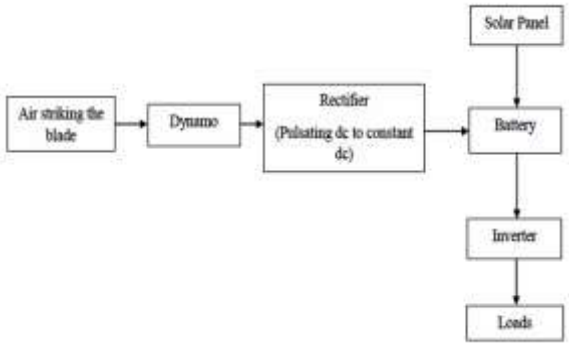

Fig1: Block diagram representing the working of VAWT and Solar panel for power generation.

Fig 1. Represents the working of vertical axis wind turbine and solar panel, It consists of vertical axis wind turbine, Dynamo, Rectifier, Solar panel and Inverter. Whenever the vehicle moves on both the sides of the highway then some pressurized air is produced due to the speed of the vehicle. This pressurized air strikes the blades of the turbine and makes the rotation. Shaft of the turbine is coupled to the generator. The electricity generated by generator is alternating quantity. Output of the generator is rectified by the rectifier and stored in battery. Solar panel is mounted on the turbine. The electricity generated by solar is dc and is stored in battery. Stored energy is converted in ac and is used for street lighting and domestic purpose.

2. ANALYSIS OF WIND TURBINE AND SOLAR PANEL

Wind turbine is a device that converts kinetic energy from the wind into electrical energy. Wind turbines consist of a set of blades attached to a rotor hub, which together form the rotor; this rotor deflects the airflow, which creates a force on the blades, which in turn produces a torque on the shaft such and the rotor rotates, which is mainly attached to a gearbox and generator. There are generally two core types of wind turbines, which are the horizontal axis wind turbine (HAWT) and the vertical axis wind turbine (VAWT). One type is built with the aim of generating electricity from wind with high speeds. On the other hand, the other type is built especially for areas with low wind speeds.

Types of On-shore wind turbines:

Horizontal axis wind turbine: the horizontal wind turbine is a turbine in which the axis of the rotor's rotation is parallel to the wind stream and the ground. Most HAWTs today are two- or three-bladed, though some may have fewer or more blades. There are two kinds of Horizontal Axis Wind Turbines: the upwind wind turbine and the downwind wind turbine.

Vertical axis wind turbines: they are closer to the ground and are ideal for catching lower speed wind in residential and urban areas. Since the rotor rotates around a vertical axis, the blades are able to catch wind blowing from any direction and, therefore, generate electricity without the use of a yaw mechanism. A smaller amount of energy and noise is produced from the turbine, which is perfect for residential homeowners who want to lower their carbon footprint. They typically require less maintenance than a horizontal axis wind turbine, which also makes it ideal for homeowners and business owners.

Darrieus wind turbines use the airfoil concept described above to turn its blades along a vertical axis. This allows the Darrieus turbine to have a virtually limitless rotation speed.

The savonius turbine is one of the simplest turbines. Aerodynamically, it is a drag type device, consisting of two or three scoops. Looking down on the rotor from above, a two-scoop machine would look like an "S" shape in cross section. Because of the curvature, the scoops experience less drag when moving against the wind than when moving with the wind. The differential drag causes the Savonius turbine to spin. Because they are drag-type devices, Savonius turbines extract much less of the wind’s power than other similarly-sized lift-type turbines. Much of the swept area of a Savonius rotor may be near the ground, if it has a small mount without an extended post, making the overall energy extraction less effective due to the lower wind speeds found at lower heights. Since the rotor is powered mainly by drag force, its maximum speed is that of the wind. This type of

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wind turbine makes for a cheap and easy do-it-yourself home project because models can be made from items found in local hardware stores.

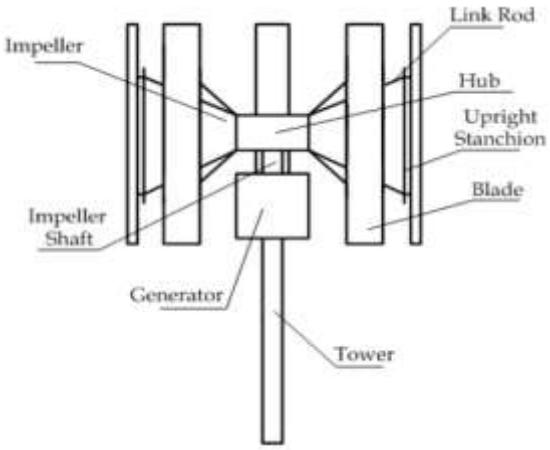

Fig2: Savonius wind turbine

Off-shore wind turbines

Offshore wind turbines are the same as the horizontal-axis wind turbine used onshore, only the rotors are much larger. Wind offshore blows much faster and more laminar than the wind on shore, because there are fewer obstructions such as buildings and hills, so offshore turbines do not need to be as tall relative to their heights as onshore wind turbines. As a result of the faster wind speeds, shows that the slight increase in wind velocity means a significant increase in power production for the offshore wind turbines.

Most offshore wind turbines are installed in shallow water, which is no more than 30 meters deep. Before piles can be driven 24 to 30 meters into the seabed, an assessment must be made to mitigate excessive environmental damages. Recently, more offshore wind turbines have been moving toward the transitional water, which has a depth between 30 and 60 meters. Simple piles will not stabilize these wind turbines against the currents, so tripod-like stands or wider-base structures must be installed.

SOLAR PANEL

Solar energy is becoming an important source of energy all over the world and especially in India. Fuel replaced by solar panel. Solar power is now the trend. All the automobile companies have their project works going in solar power to run vehicles in solar energy. Society's dependence on electricity is increasingly problematic as conventional fossil fuel reserves diminish and the danger of climate change materializes, the need for alternative energy sources is unprecedented. Solar power that is electricity generated using energy from the sun, is an attractive way to offset our reliance on electricity generated by burning fossil fuels. Since the industrial revolution, developed nations have been burning fossil fuels in ever increasing quantities. However, in the past decade two major problems with this have come to light. The first relates both to the scarcity of fossil fuel resources and the notion of energy security. The oil reserves that the world currently depends on are accepted as being a limited resource, and it is acknowledged that demand for oil will only increase as countries such as India and China increase their levels of industrialization and burgeoning middle classes demand more power. This growth will create an enormous demand on finite resources.

PV array performance depends on:

- Irradiance
- Temperature
- Shading
- Inverter

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3. DESIGN AND CONSTRUCTION

Methodology:

Fabrication*:* Fabrication of vertical axis wind turbine (Savonius type) consists of different parts which are needed to be fabricated as parts of main assembly. Following are the parts of VAWT, to be fabricated:
Base: The base is made of 50 cm height and 40 cm wide with 1inch thickness. Fabrication of base aims at providing a strong support to the turbine against the high speed wind. It is designed in such a way as to reduce the vibrations of the turbine due to turbulent winds. The base holds the rotor with fixed shaft perpendicular to rotor. The base also holds the power generating unit.
Blades: galvanized steel are used as turbine blades. The blades are approximately 1mm thick. Eighteen blades of equal length 60 cm and width of 15 cm are being used. These blades are attached perpendicular to the rotor.
Shaft: While designing the shaft of blades it should be properly fitted to the blade, the shaft should be as possible as less in thickness & light in weight. It is made up of hollow Aluminum which is having very light weight.
Generator: Dynamo is used to produce electricity of 12 volts.
Drive system: Gear mechanism is used to transmit the power from turbine to the generator. Gear ratio of 1:6 is used.

Variables:

Wind speed: This is very important to the productivity of a windmill. The wind turbine only generates power with the wind. The wind rotates the axis (horizontal or vertical) and causes the shaft on the generator to sweep past the magnetic coils creating an electric current.
Blade length: This is important because the length of the blade is directly proportional to the swept area. Larger blades have a greater swept area and thus catch more wind with each revolution. Because of this, they may also have more torque.
Base height: The height of the base affects the windmill immensely. The higher a windmill is, the more productive it will be due to the fact that as the altitude increases so does the wind speeds.
Base design: Some base is stronger than others. Base is important in the construction of the windmill because not only do they have to support the windmill, but they must also be subject to their own weight and the drag of the wind. If a weak tower is subject to these elements, then it will surely collapse. Therefore, the base must be identical so as to insure a fair comparison.
Tip speed ratio: The tip speed ratio is very important. The tip speed ratio is directly proportional to the windmill's productivity. It is how many times the blades rotate greater 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

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Fig3: Design of VAWT

The turbine blades are designed with 60 cm and made of galvanized iron, the height and width of 15 cm as shown in Fig 3. The blades are curved at 150 degrees angle. Totally 18 blades were connected to shaft with iron rod & all are placed at 20 degree each other. The hub is connected to shaft and this shaft is coupled with dynamo the number is increased in order to get high torque and easy rotation.

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 %

4. IMPLEMENTATION

Dynamo: A dynamo is an electrical generator that produces direct current electric power with the use of electromagnetism. Dynamos were the first electrical generators capable of delivering power for industry and the foundation upon which many other later electric-power conversion devices were based, including the electric motor, the alternating-current alternator, and the rotary converter. Today, the simpler alternator dominates large scale power generation, for efficiency, reliability and cost reasons.

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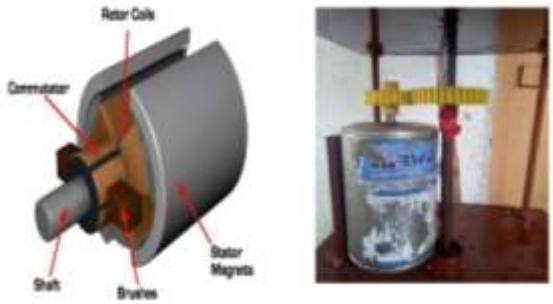

Fig4: Dynamo

Rectifier: Rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification. Physically, rectifiers take a number of forms, including vacuum tube diodes, mercury-arc valves, copper and selenium oxide rectifiers, semiconductor diodes, silicon-controlled rectifiers and other silicon-based semiconductor switches.

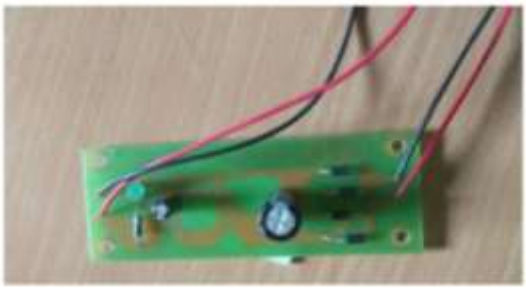

Fig5: Rectifier

Battery: A battery is a self-contained, chemical power pack that can produce a limited amount of electrical energy wherever it's needed. A battery slowly chemicals packed inside it into electrical energy, typically released over a period of days, weeks, months, or even years. The basic power unit inside a battery is called a cell, and it consists of three main bits. There are two electrodes (electrical terminals) and a chemical called an electrolyte in between them. For our convenience and safety, There are two more handy electrical terminals, marked with a plus (positive) and minus (negative) on the outside connected to the electrodes that are inside.

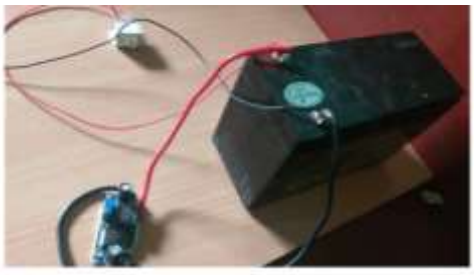

Fig6: Battery

Inverter: This is a quite simple DC to AC inverter that provides 220VAC when a 12VDC power source is provided. It can be used to power very light loads like night lamps and cordless telephones, but can be modified into a powerful inverter by adding more MOSFETs. It uses 2 power IRFZ44 MOSFETs for driving the output power and the 4047 IC as and a stable multi vibrator operating at a frequency of around 50 Hz.

The 10 and 11 pin outputs of the IC directly drive power MOSFETs that are used in push-pull configuration. The output transformer has a 9V-0-9V, 2 Amps on the secondary and 230V on the primary. Use suitable heat-sinks for MOSFETs.

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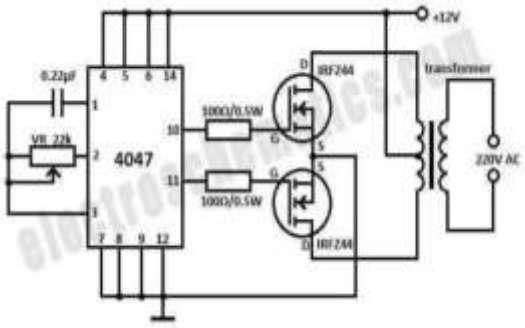

Fig7: Schematic of the DC to AC Inverter Circuit

5. RESULT ANALYSIS

In order to determine effectiveness of the products that were manufactured, the test is performed to evaluate them. To test the effectiveness of the project it is tested by installing the model near highways. Both output voltage and rate of revolution are recorded to compare the data. The following readings are obtained when there is much wind speed and the turbine is rotating with normal flow of wind. The output voltage obtained varies from 6.7 V to 10.2V.

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		

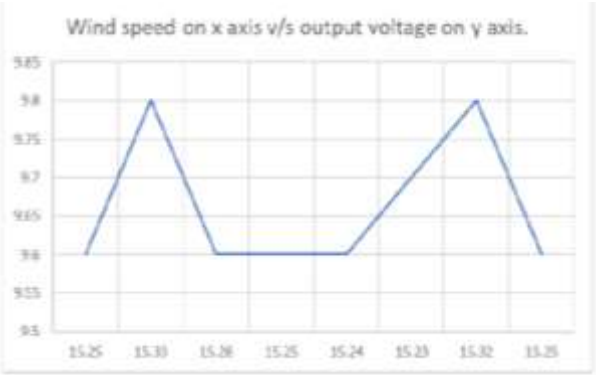

Fig8: Graph of output voltage versus wind speed

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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

Fig8: Whole set-up of VAWT and solar panel

6. CONCLUSION

Wind is a cost effective, green, renewable energy resource for power generation. Highway side application of wind turbine with improved efficiency can help us to reduce a gap between demand and supply of power. The working model of the project is combined energy source with solar system and vertical axis wind turbine system which is a good and effective solution for power generation in highways. And basically this system involves the combination of two energy system, suppose anyone source fails to generate another source will keep generating the electricity and will give the continuous power to the load. The renewable energy sources such as solar and wind energy are used to generate the electricity.

Therefore, the energy can be converted into electricity even from the moving vehicles on the highway. This project can also be developed by changing the number of blades and with the materials used. This is applicable for the entire region, and the regional parameters also are taken in to account for the better results. This idea does not require any limitations and large space like nuclear or other types of power plants, it is possible to be

ISSN: 2277-9655
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CODEN: IJESS7

built in any highway around the globe and produce more electricity. This type of power plant is the best solution for controlling the global warming.

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