Hybrid VAWT Solar Power Generation on Highway

[1]Sumendu Sinha, [2]Snehashish Chandra, [3]Praveen Kumar Singh, [4]Rituvic Pandey, [5]Prof. Y. B. Mandake
Department of Electrical Engineering
Bharati Vidyapeeth (Deemed to be) University College of Engineering, Pune

Abstract : This paper offers an effective approach to harness the wind and solar energy available on the highways with the help of a Hybrid Solar-Vertical Axis Wind Turbine (VAWT) model. The VAWT makes use of the wind turbulence created by the high-speed vehicles on highway to generate Electrical Energy. By combining VAWT and Solar Panel we aim to achieve continuous Electrical Energy generation at any hour of the day as well as at any traffic or weather condition. This generated electricity can be used for highway lighting systems, toll gates and to set up E-Vehicle charging Booths in the future. Finally, this paper shows how this combination of solar and wind energy can be useful on highways by numerical and practical computation.

***IndexTerms* – Renewable energy Resources, Highways, Wind turbulence, Solar Power**

I. Introduction

With the increase in the population and the ever-increasing demand of power, the quantity of conventional energy sources available are not enough to support the demand in the long run, hence the prices of these sources are also increasing day-by-day. Due to this Wind and Solar Energy are the fastest growing source of clean energy at present in the world. People in most parts of the world have realized the need to switch to cleaner energies for a sustainable future, which has even more promoted the application of solar and wind energy.
Wind Turbines are not a new concept, wind mills with their conventional aerofoil two or three blade system, mounted on a vertical axis, already exist. But the main problem is that there are significant fluctuations in the wind speed and the direction of these wind mills also have to be set accordingly. Similarly, solar panels are also used worldwide but a major setback being it is available for limited time in a day and depends on weather conditions. This project aims to overcome these drawbacks.
Savonius type Vertical Axis Wind Turbine (VAWT) rotate in the same direction irrespective of the direction of the wind, placing them in the highways provide an efficient way for capturing energy produced by the wind turbulence which is created by the vehicles moving at high speeds on the highways. By mounting VAWT's at the center of the roads we can harness the wind turbulence created by the high-speed vehicles on the highways in an efficient manner. The average speed of vehicles on highways are approximately 70 kmph. The power production will increase as the wind turbulence speed increases. Combining this system with solar panel will ensure continuous generation even in traffic jam, night time or any weather condition.

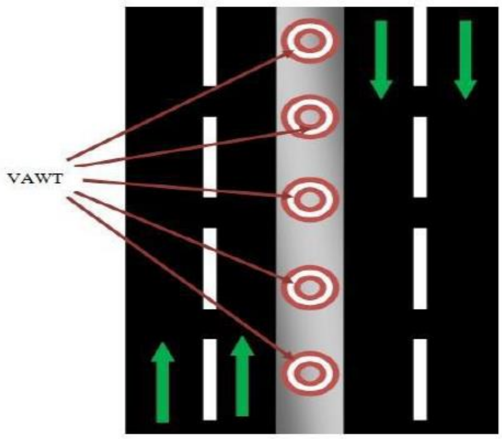

Fig.1

II. Current Senario

As of 20 FEB 2019, the total power generation capacity installed in India is 350.162 GW. Conventional energy sources are mostly used for generation, most of which is contributed by thermal power plants. In India 197.352 GW of energy is generated by thermal plants, 49.927 GW energy is generated by hydroelectric power plants, 6.78 GW energy is generated by Nuclear Power Plants, 26.025 GW through Solar Power Plants and 35.288 GW through Wind Power Plants. India is one of the most active country in renewable energy utilization in the world. Yet, we are facing a shortage of electrical energy due to the increased power demand and lack of resources. At Present we are trying to make use of more renewable resources to meet the increased power demand. Currently, lot of researches are going on in the field of using both wind and solar energy to generate power on the highway.

III. Objective of Project

- Promote utilization of renewable energy sources to generate power wherever possible.

- Find a new way of generation of electricity using wind and solar energy available on the highways.
- To harness wind energy coming from any direction.
- Develop a Stand-alone system capable of providing the power for utilization on highways.

IV. WORKING PRINCIPLE

Schematic representation of Hybrid Solar VAWT Generation System is shown in Fig. 1, the wind turbulence created by the high-speed vehicles on the highways strike the blades of the VAWT and it stars rotation. A DC Dynamo is coupled with the rotating shaft of the VAWT with the help of a gear system with tooth ratio of 4:1 to increase the rotating speed of the DC Dynamo. The Dynamo then converts the mechanical energy into electrical energy which is then stored in the battery bank for usage. Simultaneously the Solar panel installed converts the solar energy received by the sun into electrical energy which is also fed to the battery bank for storage. The battery charger circuit is a combination of diodes and Zener diodes to prevent overvoltage generation and also reverse flow of current from the battery bank. This stored electrical energy from the battery bank can then be used directly or be converted into AC by using inverters for various utilities on the highway.

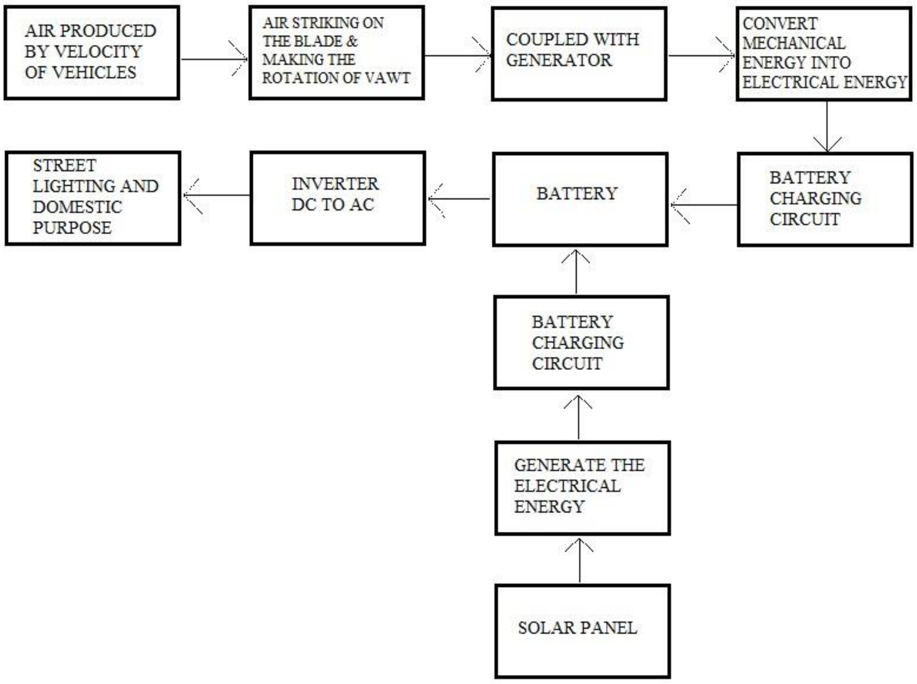

Fig.2

V. CONSTRUCTION

In this project we have used Savonius VAWT. The Savonius wind turbines are the simplest vertical axis wind turbines. It is a drag-type turbine, consisting of two or three scoops or blade. Top view of a two-scoop rotor looks like an “S”. Because of the curved shape of the scoops it experiences less drag when moving opposite to the wind direction rather than when moving in the direction of wind. The difference in the drag force leads to the rotation of Savonius wind turbine. Since these are drag-type wind turbine, Savonius wind turbines are less capable to extract the power of the wind as compared to other conventional wind turbines of the same size.

Advantages of Savonius VAWT:

1. Since its axis of rotation is vertical, the Savonius turbine is unaffected even when the direction of the wind changes.
2. At low wind speeds also Savonius wind turbines works well.
3. These are small in size and easy to build.
4. Maintenance becomes easy because the turbines are close to the ground.

- ❖ Components:
- ➢ Blades:

No. of Blades: 2
Material Used: PVC Sheet

Dimensions:

Diameter of Rotor (m)	Thickness of Blade (m)	Height of Blade (m)
0.46	0.002	1.0

Fig.3

- Shaft:

  Material Used: PVC Pipe
  Dimension:

Length (m)	Inner Diameter (m)	Outer Diameter (m)	Thickness (m)
1.2	0.03	0.042	0.006


Fig.4

- DC Generator:

  Type: Permanent Magnet DC Generator
  Rated Voltage: 6 V- 48 V

Max Rated Current: 1000 mA
Max Rated Speed: 2000 rpm
Max Output Power: 48 W

Fig.5

- Bearings:

In order to ensure smooth rotation of the Shaft, ball-bearing is used, which reduced the friction loss.
Type of Bearing: Ball-Bearing
Diameter of Bearing: 0.03 m

Fig.6

- Solar Panel:
Rated Output Voltage: 12 V
Rated Output Power: 5 W
Material: Polycrystalline Silicon

Fig.7

- Gear System:

A gear system with a gear ratio of 1:4 is used to increase the speed of rotation of the DC Generator by 4 times the rotation speed of the rotor shaft. This increases the output produced by the model.

Fig.8

- Charger Circuit:

Fig.9

The charge controller prevents damage to the batteries. If the batteries are near to full charge or is completely charged but the wind is blowing strongly, the charging current needs to be reduced to prevent damage to the battery. The 1 Amp diode bridge rectifier is shown in Fig.9. The charge controller will divert some power from the generator away from the battery and into a dummy load. This can be a series of bulbs or a heating coil in the simplest systems this excess energy is wasted using this circuit we can store energy in battery without reverse flow and current.

VI. BASIC EQUATIONS

The estimation of maximum power of the rotor of wind turbine is done by using Betz's law

$Ps = 1/2\rho \cdot A \cdot v3 \cdot Cp = 0.36 \cdot h \cdot D \cdot v3$. W ……..[1]

$\rho = 1.2$ kg/m3 (density of air)

$A = h \cdot D$ (rotor blade sweep area)

Cp = 0.593 (Betz coefficient)

However, there are aerodynamic and mechanical losses are in the order of 50%. Our rotor shaft power equation then becomes

$Ps = 0.18 \cdot h \cdot D \cdot v3$. W ……...[2]

The rotational speed is defined as

$n = (60/2\pi) \cdot \omega$ rpm ………[3]

Where $\omega = \lambda \cdot v/r$ is the angular velocity in units of rad/sec,

$r = D/2$ (radius of the rotor)

$\lambda = 1$ (tip-speed ratio)

Furthermore, the torque at the rotor shaft is given as

$\tau s = Ps/\omega$. Nm ………[4]

Now, we can calculate the key parameters of the rotor using the above equations.

VII. RESULTS

1) Theoretical Results:

Assuming that the height of the rotor is h=1m and the average wind velocity of 4.4m/s.
Following are the values of the key parameters at different rotor diameter.

Rotor Diameter (m)	Radius (m)	Power (W)	ω (rad/s)	Speed (rpm)	Torque (Nm)
0.30	0.150	5.04	29.60	282.65	0.17
0.35	0.175	5.88	25.37	242.20	0.23
0.40	0.200	6.72	22.20	211.95	0.30
0.45	0.225	7.56	19.73	188.40	0.38
0.50	0.250	8.40	17.76	169.56	0.47
0.55	0.275	9.24	16.14	154.14	0.57

2) Practical Results:

Speed of Wind (m/s)	Output Voltage (V)	Output Current (mA)	Output Power (W)
4.1	6.3	657	4.13
4.6	9.1	712	6.48
4.9	9.3	748	6.96
5.3	9.5	799	7.59

The results are recorded assuming that, 100 vehicles with average speed of 60 kmph to 80 kmph travel at uniform interval creating a constant wind speed of 4.4 m/s for a finite duration

VIII. CONCLUSION

Hence, results are acquired on the wind turbulence created extensively by the high-speed vehicles on either side of the highway. These acquired results show that the Hybrid Solar-VAWT should be kept on the median of the highways, i.e., the dividers. The Hybrid Solar-VAWT is capable of producing power which can be able to charge a 12 Volts battery in 6-8 hours. A single Hybrid Solar-VAWT may not be able to generate a significant amount of power but using a collection of these placed on the dividers of the highways has the capability to produce a significant amount of electrical energy that we can use to energize the highway lighting system, tool booths and provide energy for charging booths for E-Vehicles in the future. This concept promotes sustainable and environment friendly generation of electricity.

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