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Vertical Axis Wind Turbine for Generation of Electricity through Highway Windmill

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ABSTRACT

In this paper our effective approach is to harness electrical energy from the highway by using of vertical axis wind turbine. The smart windmill consists of a stationary shaft which is mounted on the ball bearing on the top and bottom end of the shaft The curvy darrieus blades are connected to the two ends of bearing which is able to rotate on its own axis. The dynamo is connected to the either upper part or lower part of the wind turbine which works on Fleming's left hand rule of Electromagnetic induction. In highway both at day as well as at night time vehicles will be moving at very high speed. By this method the overall cost per unit of energy produces is less than the cost of new coal, natural gas and its installation. So the implementation can be made easier than any other methods.

Keywords: *Blade design, Curvy Darrieus Blade, Clean energy ,Vertical Axis Wind Turbine, Highway Wind Turbine.*

1. INTRODUCTION

Wind energy is the fastest growing source of clean energy worldwide. This is partly due to the increase in price of fossil fuels. The employment of wind energy is expected to increase dramatically over the next few years according to data from the Global Wind Energy Council. A major issue with the technology is fluctuation in the source of wind. There is a near constant source of wind power on the highways due to rapidly moving vehicles. The motivation for this project is to contribute to the global trend towards clean energy in a feasible way. Most wind turbines in use today are conventional wind mills with three airfoil shaped blades arranged around a vertical axis. These turbines must be turned to face into the wind and in general require significant air velocities to operate. Another style of turbine is one where the blades are positioned vertically or transverse to the axis of rotation. These turbines will always rotate in the same direction regardless of the fluid flow.

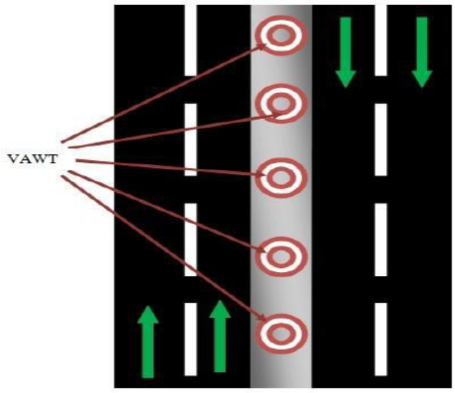

Fig.1: Turbine on highway divider

A very novel way of re-capturing some of the energy expended by vehicles moving at high speeds on our nation's highways We know how

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much air turbulence is generated by vehicles moving at speed particularly trucks. This would involve mounting vertical axis wind turbines at the centre of the roads that would be driven by the moving air generated by the passing traffic. The excess energy generated could be fed back into the grid or power up the villages nearby. While we'll never recover much of the energy wasted pushing air out of the way of a sixteen wheeler, even a fraction could be a significant source of power. Average vehicle speeds on the valley highways are approximately 70 mph. This power production estimate will increase exponentially with an increase in wind turbulence speed. We believe that the wind stream created over the freeways by our primary mode of transportation will create an average annual wind speed well beyond the baseline of 10 mph. In Fig. 1 shows rough sketch of highway wind turbine located on divider. Power generation is less in the downwind sector of rotation. Consideration of the flow velocities and aerodynamic forces shows that, nevertheless, a torque is produced in this way which is caused by the lift forces. The breaking torque of the drag forces in much lower, by comparison. In one revolution, a single rotor blade generates a mean positive torque but there are also short sections with negative torque.

2. CURRENT SCENARIO

As of 31 March 2014, total installed capacity in India is 255.012 GW. Most of the energy requirement is served by the conventional sources, a major part of which is contributed by thermal power plants. In India almost177.742 GW of energy is generated by thermal plants, 40.799 through hydroelectric power plants, 4.78 GW through Nuclear Power Plants and remaining 31.692 GW through other renewable source. India's electricity sector is amongst the world's most active players in renewable energy utilization. India stands 5th in wind power generation with an installed capacity of 21.136 GW. Even though, we are facing a deficit of electrical energy due to lack of resources as well as the increased power demand. Currently, we are trying to incorporate more renewable sources into the grid to support the increased power demand. As a part of it a lot of researches are going on in the field of wind power generation and the researchers are trying to exploit the field of highway wind power generation as highway is one of the potential source of wind energy.

3. OBJECTIVE OF THE PROJECT

- Incorporation of more renewable energy to the power system.
- Design of a new method of generation of electricity using the wind energy generated by the moving vehicles on the highways.
- Development Stand-alone system for providing the power to the highways.

4. WORKING PRINCIPLE

Schematic diagram of the proposed project is given in fig. 2. The kinetic energy of the wind is converted into rotational energy using vertical axis wind turbine which is either coupled directly or through gear. Rotational energy from the turbine is converted into electrical energy by the permanent magnet synchronous generator whose output is fed to an IGBT based chopper. Since the wind speed is not constant, the output of the generator will be varying frequently. Chopper regulates the output of the generator and charges the battery. Stored energy in the battery can be used to light LED based street lights using an LED driver circuit.

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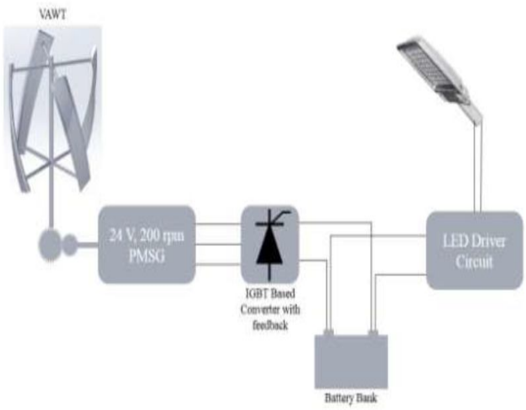

Fig.2: Schematic Diagram of the Project

5. CONSTRUCTION

5.1 Blades

Wind turbine blades have on aerofoil type cross section and a variable pitch. While designing the size of blade it is must to know the weight and cost of blades. The ideal wind generator has an infinite number of infinitely thin blades. In the real world, more blades give more torque, but slower speed, and most alternators need fairly good speed to cut in. 2 bladed designs are very fast (and therefore perform very well) and easy to build, but can suffer from a chattering phenomenon while yawing due to imbalanced forces on the blades. 3 bladed designs are very common and are usually a very good choice, but are harder to build than 2-bladed designs .Going to more than 4 blades results in many complications, such as material strength problems with very thin blades. Even one-bladed designs with a counterweight are possible.

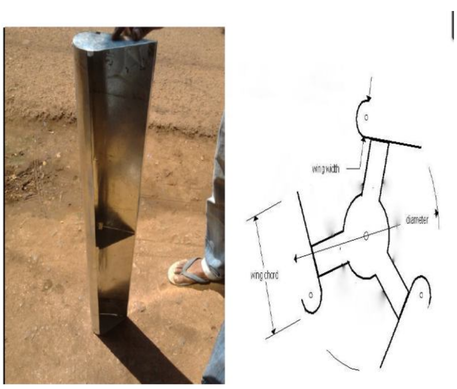

Fig.3: Turbine Blade

This number defines how much faster than the wind speed the tips of your blades are designed to travel. Your blades will perform best at this speed, but will actually work well over a range of speeds. The ideal tip speed ratio depends on rotor diameter, blade width, blade pitch, RPM needed by the alternator, and wind speed. Higher TSRs are better for alternators and generators that require high rpm but the wind speed characteristics at your particular site will make a big difference also. If in doubt, start in the middle and change your blade design depending on measured performance. The sketch and photo of designed blade is shown in Fig. 3.And Detail dimensions of blade is shown in Tab.1.

Table-1: Designed Blade Dimensions

Sl. No.	Description	Dimension
1	Length	1000mm
2	Width	163.10mm
3	Wind Chord	163mm
4	Wind Width	76.72mm

5.2 Center Shaft

The shaft of the turbine consists of a single 1500mm length of steel measuring 25mm in diameter. The use of steel over a lighter metal such as cast iron was based on the availability of materials. The top and bottom ends mild steel of length 1inch each are respectively are fixed to give strength to the hollow shaft. A solid shaft rotating at 75 rpm is assumed to be made of mild steel. The yield strength of a mild steel shaft material (C50) from design data is 380Mpa [1]. (380/(2x 2)) The safe load is 300N (Approx 30Kg).The shaft of length 1500mm is subjected to bending and torsion stresses. The diameter of shaft taken is 25 mm is safe after testing both bending and torsion [2] .

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5.3 Generator

For generation of electricity from the designed our vertical axis wind turbine, we chose a dynamo which has the capacity to light a bulb of 12 V. The selected dynamo is shown in Fig.4

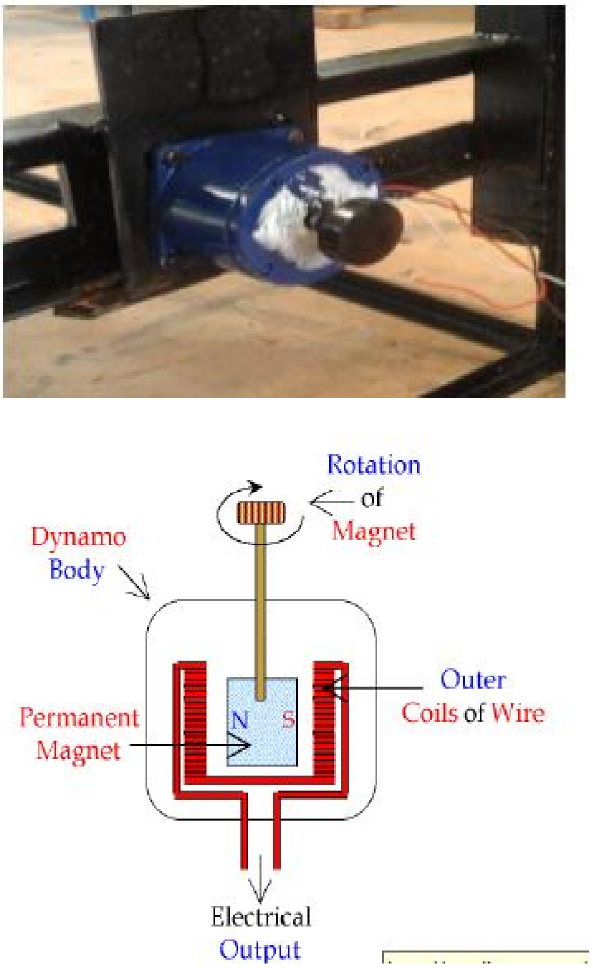

Fig.4: Generator

5.4 Bearing

For the smooth operation of Shaft, bearing mechanism is used. To have very less friction loss, the two ends of shaft are pivoted into the same dimension bearing. The Bearing has diameter of 2.54cm. Bearings are generally provided for supporting the shaft and smooth operation of shaft. The Fig.5 shown the ball bearing used in the turbine.

Fig.5: Ball Bearing

5.5 Electrical Components

The charge controller is there to prevent damage to the batteries. If the batteries are near to full charge, but the wind is blowing strongly, the charging current needs to be reduced to prevent damage to the battery. The 1 Amp diode bridge rectifiers is shown in Fig.6.

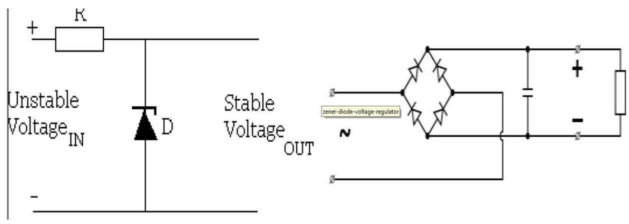

Fig.6 : Amp diode bridge rectifier

The charge controller will divert some power from the generator away from the battery and into a dump load. This can be anything from a series of bulbs to 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.

6. ADVANTAGES OF DARRIEUS-VAWT

A key challenge for Darrieus-VAWT is that they are generally located close to settlements where wind speeds are often low and turbulent as a result of surrounding trees, buildings and other infrastructure. Designing reliable small wind turbines to perform in these conditions where noise levels must be very low is a challenge. As a result, there is increased interest in vertical-axis technologies given that:

1. They are less affected by turbulent air than standard horizontal-axis wind turbines.
2. Have lower installation costs for the same height as horizontal-axis wind turbines.
3. They require lower wind speeds to generate, which increases their capacity to serve areas with lower than average wind speeds.
4. They rotate at one-third to onequarter the speed of horizontal-axis turbines, reducing noise and vibration levels, but at the expense of lower efficiency.

7. TOTAL INSTALLED CAPACITY

The wind power industry has experienced an average growth rate of 27% per year between 2000 and 2011, and wind power capacity has doubled on average every three years. A total of 83 countries now use wind power on a commercial basis and 52 countries increased their total wind power capacity in 2010 (REN21, 2011). The new capacity added in 2011 totalled 41 GW, more than any other renewable technology (GWEC, 2012). This meant total wind power capacity at the end of 2011 was 20% higher than at the end of 2010 and reached 238 GW by the end of 2011.

Europe accounted for 41% of the global installed wind power capacity at the end of 2011, Asia for 35% and North America for 22%. The top ten countries by installed capacity accounted for 86% of total installed wind power capacity worldwide at the end of 2011 (Figure 3.2). China now has an installed capacity of 62 GW, 24 times the capacity they had in 2006. China now accounts for 26% of global installed capacity, up from just 3% in 2006. Total installed capacity at the end of 2011 in the United States was 47 GW (20% of the global total), in Germany it was 29 GW (12%), in Spain it was 22 GW (9%) and in India it was 16 GW (7%).

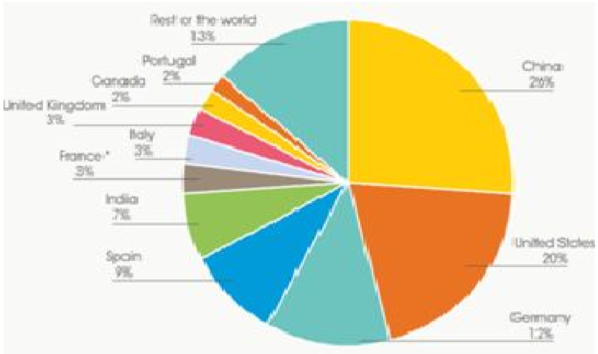

Fig.7: Total Installed Capacity inwords

8. RESULTS

The results are taken on the basis that, 100 vehicle travelled at average speed of 70 km/hr at regular average wind speed of 4.5 m/s for the duration of 2hrs. The electric power generated from designed wind turbine is approximately 200 Watt –hr.

9. CONCLUSION

Conclusively, extensive data is collected on wind patterns produced by vehicles on both sides of the highway. Using the collected data, a wind turbine is designed to be placed on the medians of the highway. Although one turbine may not provide adequate power generation, a collective of turbines on a long strip of highway has potential to generate a large amount of energy that can be used to power streetlights, other public amenities or even generate profits by selling the power back to the grid. This design concept is meant to be sustainable and environmentally friendly. Additionally, a wind turbine powered by artificial wind has a myriad of applications.

Theoretically any moving vehicle can power the turbine such as an amusement park ride. The highway wind turbine can be used to provide power in any city around the globe where there is high vehicle traffic.

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