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Highway Power Generation using Low Cost Vertical Axis Wind Turbine [VAWT]

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Abstract:
In this paper the fabrication of prototype model of Savonius type Vertical Axis Wind Turbine (VAWT) is made using easily available materials like, front wheels of bicycle with ball bearing, half cut PVC pipes, wooden base etc. The CADD model of the VAWT is prepared. This VAWT is placed in the medians of highway. The vehicles from both sides of medians accelerate the wind thus increasing its kinetic energy which forces the turbine blades to rotate in clock wise direction. This drives the rotor which is connected to a DC generator, thus producing electricity. The effort is made to produce electricity at low cost. This electricity can be used for multiple applications like smart highway system, toll booths, highway lightening, etc. This VAWT also acts as a barrier for high beam focus lights emitted by vehicles from opposite lanes, thus reducing the risks of accidents.

Keywords: Vertical axis wind turbine, Kinetic energy of wind, Car dynamo, Highway medians.

I. INTRODUCTION

Wind energy is considered the fastest growing clean energy source. In today's life the demand on electricity is much higher than that of its production. In this 21st century there are many methods to produce energy. In renewable energy field sector, wind turbines play an important role in energy production. 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.

WIND ENERGY SCENARIO IN INDIA

Wind energy program was started in India by the end of the 6th five yearly plan during 1983-84 and in the last few years it has increased significantly. The main objective of this program was the commercialization of wind energy generation, support research and development, deliver help to wind projects and to build awareness among people. Ministry of Non Renewable Energy (MNRE) has done various amendment regarding incentives, schemes and policies for wind energy under this program. India is relatively beginner to the wind energy sector as compared to Denmark or USA. But Indian policy support for wind energy has directed India and it ranked fourth with largest installed wind power capacity [12]. The total installed power capacity is 26867.11 MW on April 30, 2016[13] and now India is just after China, USA and Germany. Global installed wind power capacity displays India‘s better performance in wind energy sector. The five leading wind power countries are China, USA, Germany, Spain and India and they together represent a share of 73.5% of the global wind capacity. As per MNRE, wind power accounts for the largest share of renewable power installed capacity i.e.70 percent (2012), other than the other renewable sources. The total installed wind power capacity in India reached 26.9 GW in April, 2016. A rapid growth in wind power installation has been measured in southern and western states in India. A need for about 350- 360 GW of total energy production capacity was reported by the Central Electricity Authority in its National Electricity Plan (2012), by the year 2022[15]. Only onshore wind potential has been utilized so far by India. Despite the fact that India is having long coast line over 7500 km, we have not yet appointed our offshore wind source for energy generation. The Capacity Utilization Factor (CUF) of offshore wind turbines is much higher other than the onshore turbines for the reason that of the high offshore wind speed [13]. Offshore Wind Steering Committee was formed by MNRE in August 2012, which passed a draft of the National Offshore Wind Energy Policy in May 2013.

WIND TURBINES

The formal definition for a wind turbine is it is a type of device that transforms kinetic energy mainly from the wind into electric power. 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. 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 around a horizontal axis, which is mainly attached to a gearbox and generator. These are inside the nacelle, which is located at the top end of the tower, along with several other electrical parts. The generator generates electricity, which is moved down from the tower and out to an available transformer, so that it can be converted from the output voltage (usually about 700V) to the some voltage for either the countrywide grid (33000V) or for any personal use (about 240V).

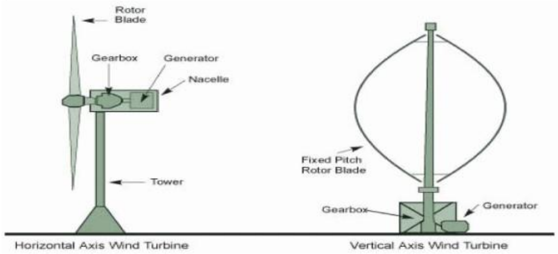


Figure.1. Wind turbines

II. TYPES OF WIND TURBINES

HORIZONTAL AXIS WIND TURBINES

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. The HAWT works when the wind passes over both surfaces of the airfoil shaped blade but passes more rapidly at the upper side of the blade, thus, creating a lower-pressure area above the airfoil. The difference in the pressures of the top and bottom surfaces results in an aerodynamic lift. The blades of the wind turbine are constrained to move in a plane with a hub at its center, thus, the lift force causes rotation about the hub. In addition to the lifting force, the drag force, which is perpendicular to the lift force, impedes rotor rotation.

Figure.2. HAWT

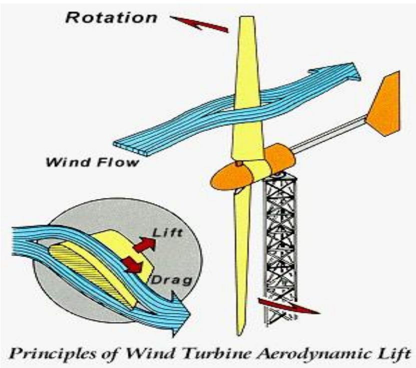


Figure.3. Working of HAWT

- **Types of HAWT:**

Upwind Turbine

Figure.4. Upwind Turbine

The upwind turbine is a type of turbine in which the rotor faces the wind. A vast majority of wind turbines have this design. Its basic advantage is that it avoids the wind shade behind the tower. On the other hand, its basic drawback is that the rotor needs to be rather inflexible, and placed at some distance from the tower. In addition, this kind of HAWT also needs a yaw mechanism to keep the rotor facing the wind.

Downwind Turbine

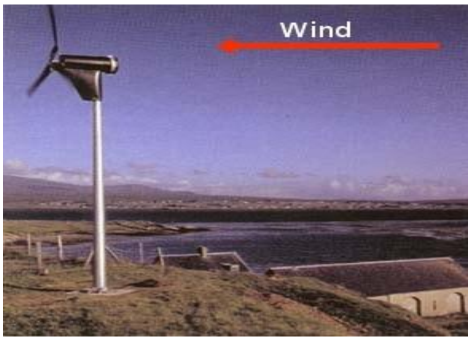


Figure.5. Downwind Turbine

The downwind turbine is a turbine in which the rotor is on the downwind side (lee side) of the tower. It has the theoretical advantage that they may be built without a yaw mechanism, considering that their rotors and nacelles have the suitable design that makes the nacelle follow the wind passively. Another advantage is that the rotor may be made more flexible. Its basic drawback, on the other hand, is the fluctuation in the wind power due to the rotor passing through the wind shade of the tower. Currently high speed propeller wind turbines are commonly used as horizontal axis turbines because of their excellent aerodynamic efficiency.

VERTICAL AXIS WIND TURBINES

The VAWT is a turbine in which the axis of rotor is perpendicular to the wind stream and the ground. VAWT commonly function nearer to the ground, and has the benefit of enabling placement of heavy equipment, such as the gearbox and generator, close to the ground level and not in the nacelle. However, the winds are lower near ground level hence for a similar wind and capture area, a less amount of power is generated. Another benefit of a VAWT is that it does not need a yaw mechanism, because it can harness the wind from all directions. This benefit is outweighed by numerous other limitations, such as: time varying power output because of change of power in a single blade rotation, the requirement for guy wires to support the main tower and the fact that the Darrieus VAWT are do not self-start like HAWTS.

- **Types of VAWT**

Darrieus Turbine

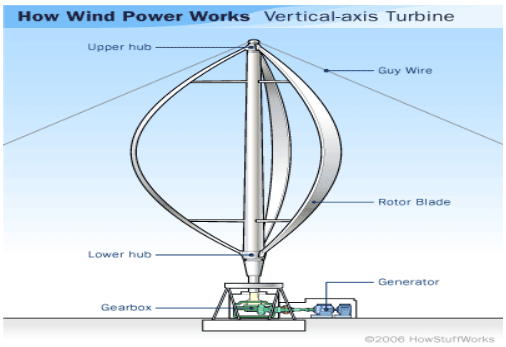


Figure.6. Darrieus Turbine

The Darrieus turbine is composed of a vertical rotor and several vertically oriented blades. A small powered motor is required to start its rotation, since it is not self-starting. When it already has enough speed, the wind passing through the airfoils generate torque and thus, the rotor is driven around by the wind. The Darrieus turbine is then powered by the lift forces produced by the airfoils. The blades allow the turbine to reach speeds that are higher than the actual speed of the wind, thus, this makes them well-suited to electricity generation when there is a turbulent wind.

Giromill Turbine

Figure.7. Giromill Turbine

The Giromill Turbine is a special type of Darrieus Wind Turbine. It uses the same principle as the Darrieus Wind Turbine to capture energy, but it uses 2-3 straight blades individually attached to the vertical axis instead of curved blades. It is also applicable to use helical blades attached around the vertical axis to minimize the pulsating torque.

Savonius Turbine

Figure.8. Savonius Turbine

The Savonius wind turbine is one of the simplest turbines. It is a drag-type device that consists of two to three scoops. Because the scoop is curved, the drag when it is moving with the wind is more than when it is moving against the wind. This differential drag is now what causes the Savonius turbine to spin. Because they are drag-type devices, this kind of turbine extracts much less than the wind power extracted by the previous types of turbine.

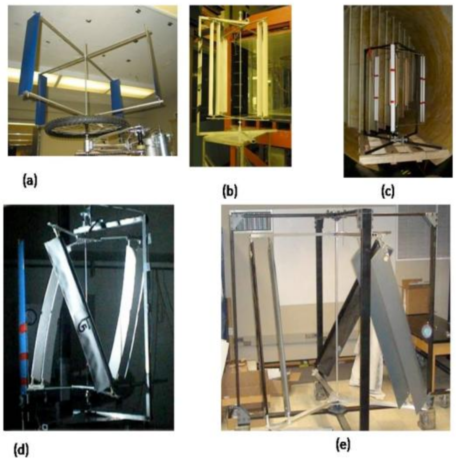


Figure.9. Different models of Vertical Axis Wind Turbine

III. PROBLEM DEFINITION

In India the need of electricity is more than its production. The focus on energy generation from Renewable Energy Resources has increased significantly in the recent years in the wake of growing environmental pollution, rising energy demand and depleting fossil fuel resources. Different sources of renewable energy include biomass, solar, geothermal, hydroelectric, and wind energy. Among these resources wind has proved to be a cheaper alternative energy resource and hence extensive research efforts have been put to improve the technology of electricity generation through wind energy. The world has enormous potential of wind energy that should be utilized for electricity generation. Indian Renewable Energy Development Agency (IREDA) and the wind industry are working together to accomplish the improvements through various research and development programs. In areas where favorable sites exist, it has already been preferred over conventional fossil fuels resources for electricity generation. Wind power is now the world‘s fastest growing energy resource utilized. The fixed wind powered electricity generation systems in use, till now are dependent on wind direction and the force of the wind. But the wind is not available at all places and all time throughout the year. Also 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, trains or airplanes, which is available throughout the year at various places and with sufficient force of wind. Therefore this invention provides a solution to the problem for generating electricity in this manner. On keeping prime focus on the heavy duty automobiles on highways/expressway, we found out that there is large amount of wind pressure generated on these roads due to wind disturbance/ wind turbulence created by these automobiles. As any automobile passes along the path, it creates a very huge air pressure on the nearby surrounding areas. This high pressure of wind is till now of no use especially in India. Till now there is no as such technology developed and implemented in India to utilize this high pressure column of wind so generated. With concern to this, we had tried to develop a vertical axis wind turbine which works on the principle of these highway wind energy.

IV. OBJECTIVE OF THIS PROJECT

The main objective 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. Increased turbulence levels yield greater fluctuations in wind speed and direction. Unlike traditional horizontal axis wind turbine (HAWT), vertical axis wind turbine effectively captures turbulent winds which are typical in urban settings. An effort is made to fabricate a vertical axis wind mill of higher output capacity. Our aim is to design and fabricate the wind turbine using easily available, low cost raw materials like wheels of cycle with inbuilt ball bearing, half cut PVC pipes, etc. This wind turbine is made to capture the maximum of wind energy in any direction by placing it at optimum place and by considering both the cost and safety of the system. This system can be used in huge number to generate the huge amount of useful electrical energy. This energy can be stored and transferred to nearest rural places where we can fulfill the demand of electricity. The thought of design directs us to look into the various aspects such as manufacturing, noise, cost which leads us to our additional aim of analyzing the system to overcome the usual technical glitches. The project brief involves the design of a small scale wind turbine that can be easily mass produced and fitted on every highway medians to aid electricity consumption.

V. 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 plywood 6 feet long and 3 feet 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.

Frame- The frame is made using mild steel rectangular [20cm*40cm] pipes. Two six feet long pipes are attached perpendicular to the base. Two four feet long pipes are attached parallel to the base. These rectangular pipes are attached using L clamps with suitable nut and bolts. The frame is designed in such a way as to provide required strength and support to the turbine against the rotation of blades and force of wind.

Blades- In this project 5 inch, half cut PVC pipes are used as turbine blades. The blades are approximately 3mm thick. Five blades of equal length are being used. The analysis is made using a set of three, four and five blades. These blades are attached perpendicular to the rotor [cycle wheel] using clamps with nut and bolt arrangement.

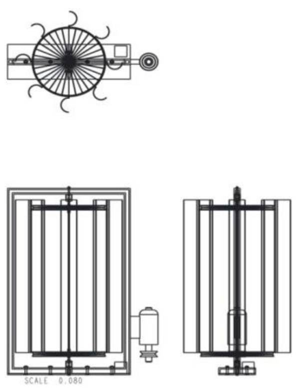
Rotor- Two front wheels of the cycle are used as the rotor. These wheels are made up of stainless steel material in order to resist the corrosion. The diameter of the wheels is 300 cm. These wheels consist of ball bearing which allows easy rotation. These wheels are attached one to the top of frame and other to the base. They are supported by the fixed shaft.

Generator- Dynamo of car is used to produce electricity of 12 volts.

Drive system- Belt drive system is used to transmit the power from turbine to the generator. Gear ratio of 1:10 is used.

VI. Creo models of designed Vertical Axis Wind Turbine.

2D Views of VAWT



5.2.2 Isometric view of VAWT.

Figure.10. Assembled Creo model of VAWT.

VII. Fabricated VAWT placed in the medians of NH4

VIII. WORKING

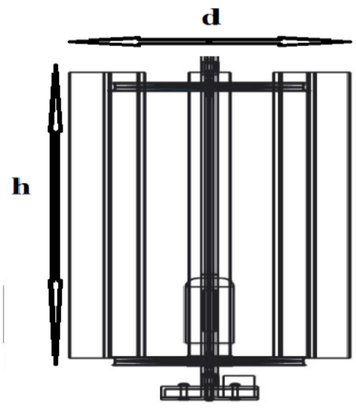
- Here the Kinetic Energy from wind force produced due to the fast moving vehicles from both lanes, forces the wind turbine to rotate in clockwise direction with certain rpm.

- This in turn forces the alternator to rotate in same clockwise direction with 10 times faster than the turbine speed, thus generating electricity which is stored in 12 volt car battery.

- This energy can be multiplied by implementing a series of wind turbines.

- The stored energy can be utilized for smart tollbooth system, smart toilets, highway lightening, etc

IX. CALCULATIONS



- Area of the turbine = d*h= 0.6*1.5=0.9 square meters.
- N1= speed of driver in rpm [Rotor].
- N2= speed of driven in rpm [Dynamo].

Table.1. Observations

Sl. No.	Wind speed m/s	N2 in rpm	Battery condition
1	12.77	342	Charging
2	15.65	456	Charging
3	20.34	631	Charging

- **Average wind speed = 16.25 m/s**
- **Average speed of rotor N2 = 476.33 rpm**
- **Discharge:**
  Q = A*V
  Q = 0.9*16.25
  Q = 14.625 m^3/min
- **Input power P = ½*ρ*A*V^3 in watts.**
  ρ- Air density, (assume 1.093 kg/m3)
  V- Wind velocity in m/s
  P = 0.5* 1.093*0.9*$(16.253)^3$
  P = 21111.705 watts.
- **Gear ratio:**
  N1/N2 = D2/D1
  N1/N2 = 60/600
  N1/N2 = 0.1
  Therefore N1= 0.1N2
- **Output power of Turbine:**
  P = 2111.705*0.1
  P = 211.17 watts

Table.2. Wind velocity and the power output

Sl. No.	Wind velocity (m/s)	Power output (in watts)
1	12.77	102.42
2	15.65	188.5
3	20.34	413.89

X. CONCLUSION

Thus at minimum wind speed of 12.77 m/s i.e, 46 km/hr the turbine is rotating at 342rpm which accounts for 102.4 watts according to the equation. Hence one can obtain an output of 500watts to 1kilowatts of power with an average wind speed of 20 to 30m/s. Our work and the results obtained so far are very encouraging and reinforce the conviction that wind energy conversion systems are practical and potentially very contributive to the production of clean renewable electricity from the wind even under less than ideal sitting conditions. The VAWT is designed and fabricated in such a way that it can able to capture wind from all the direction. The Savonius vertical axis wind turbine designed can be located at the highways medians to generate electricity, powered by wind. The heavy vehicle traffic gives it an advantage for more wind opportunity. With the idea of putting it on highway medians, it will power up street lights and or commercial use. This turbine can also be a barrier for the high intensity light coming from the vehicles of other lanes and hence reduce the risk of accidents. The obtained energy can be multiplied by placing the wind turbines in series. In most cities, highways are the faster routes, so this energy can be efficiently used for many purposes.

XI. SCOPE FOR FUTURE WORK

A more efficient Wind turbine can be developed using the following measures:

- Optimizing the design of blades so as to give better aerodynamics.
- Using a more efficient alternator which produces more voltage for low rpm.
- Using gear mechanisms to increase rpm for alternator input and hence can have higher power output from the alternator.
- Structural fabrication should be more accurate in order to have proper functions of windmill.
- This turbine can also be fixed near high speed railway tracks in order to get more energy output.

XII. REFERENCES

[1]. NiranjanaSJ “Power Generation by Vertical Axis Wind Turbine” International Journal of Emerging Research in Management &Technology ISSN: 2278-9359 (Volume-4, Issue-7).

[2]. Mr.Mukesh Kumar Sharma. “Assessment of Wind Energy Potential from Highways”. International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 8, October - 2012 ISSN: 2278-0181

[3]. Mark Paluta, Dan Reitz, Ryan Snelling, Joe Gadient “Design and Fabrication of a Vertical Axis Wind Turbine University of Notre Dame Department of Aerospace and Mechanical Engineering”.

[4]. H. Fernández, A. Martínez, V. Guzmán and M. Giménez. - Wind Turbine Generation System Implemented with a Car Alternator for Use in Isolated Locations. RE & PQJ, Vol. 1, No.2, April 2004

[5]. Arvindkumar; Sandeep kumarsingh – Wind Power Generation on Highway.

[6]. Anil Prasad; Asifulla A; Suhas S; Satish Karemmanavar. “Design and Fabrication of Vertical Wind Turbine For Power Generation At Highway Medians”. Bapuji Institute Of Engineering And Technology, Davangere.

[7]. XiaonaJi, Jorag Schluter, “Design and Analysis of small-scale Vertical Axis Wind Turbine”, Nanyang Technological University.