Electricity Generation Using Hybrid Power

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Abstract:

The project's objective is to design a wind turbine to recapture wind energy from vehicles on the highway. Wind energy is considered the fastest-growing clean energy source however; it is limited by variable natural wind. Highways can provide a considerable amount of wind to drive a turbine due to high vehicle traffic. This kinetic Energy is unused. Research on wind patterns was used to determine the average wind velocity created by oncoming vehicles. The wind turbines are designed to be placed on the medians therefore fluid flow from both sides of the highway will be considered in the design. Using all of the collected data, existing streetlights on the medians can be fitted with these wind turbines. The design of the turbines consists of blades, collars, bearings, a shaft, gears, and a generator. Additionally, since the wind source will fluctuate, a storage system for the power generated was designed to distribute and maintain a constant power source. Ideally, the turbine can be used globally as an unlimited power source for streetlights and other public amenities.

Keywords: wind energy, high vehicle traffic, turbines, blades, collars, bearings, etc.

.**Introduction :**

Wind energy is the fastest-growing source of clean energy worldwide. This is partly due to the increase in the 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 windmills with three airfoil-shaped blades arranged around a vertical axis. These turbines must be turned to face the wind and in general, require significant air velocities to operate. Another style of the 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.

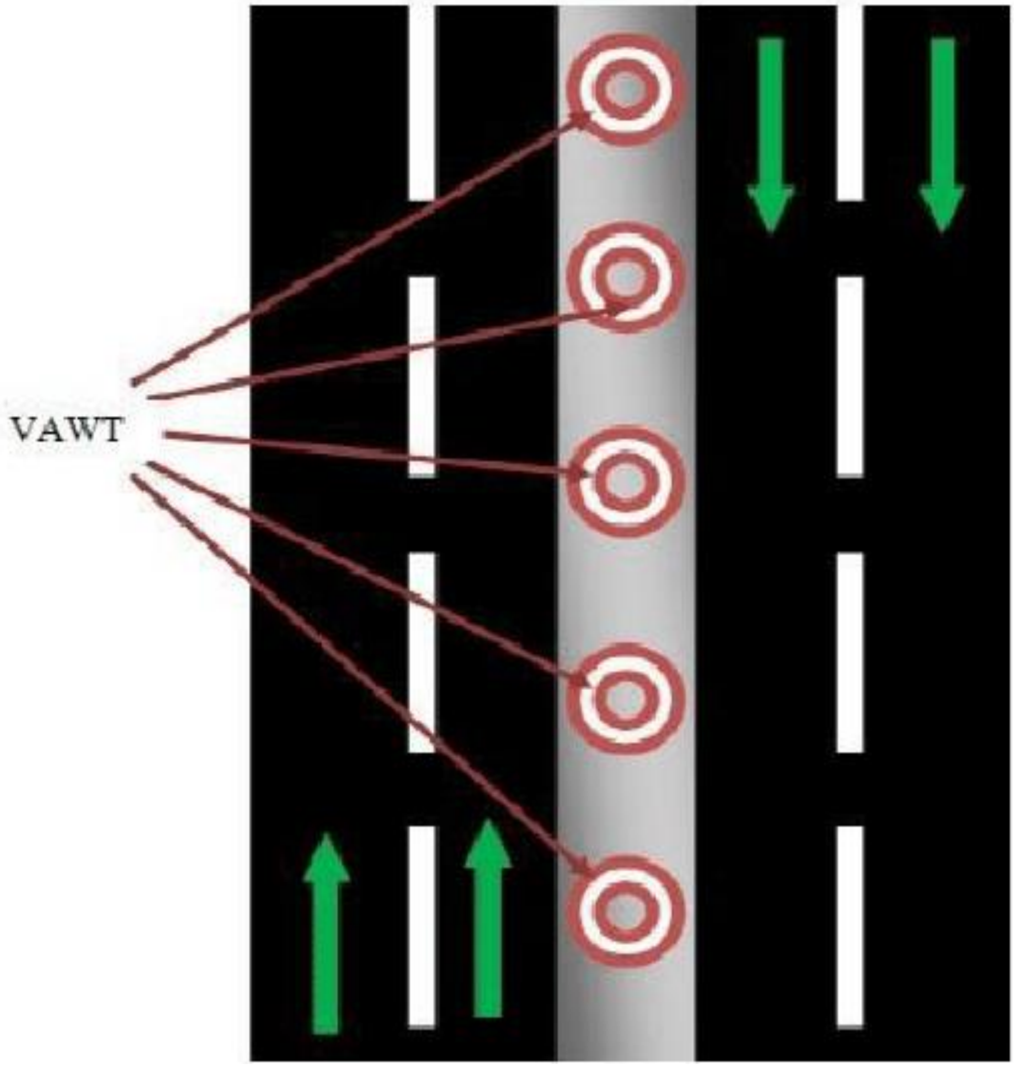

Figure 1 Turbine on highway divider

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 much air turbulence is generated by vehicles moving at speed, particularly trucks. This would involve mounting vertical-axis wind turbines at the center 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. Fig. 1 shows a rough sketch of a highway wind turbine located on the 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 is 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.

Methods:

2.1 Wind Turbine Working Principle

The wind is caused by air flowing from a high-pressure region to a low-pressure region. Pressure difference is due to uneven heating of the Earth's Surface. Because air has mass and it moves to form wind, it has kinetic energy. Every wind generator, whether they produce enough energy to power a city or to power a small radio, works on these same basic principles:

- The wind blows
- Blades attached to an alternator/generator experience the force of lift and begin to spin
- The generator's vane (tail) causes it to turn into the wind
- The spinning creates electricity for us to use directly or to charge batteries.

2.2Aerodynamic Principles of Wind Turbines

- Nomenclature

CL Lift coefficient

CD Drag coefficient

α Angle of attack

ρ Air density

r Local blade radius.

L Blade chord

θ Twist angle

φ Inflow angle

ω Blade angular velocity

An axial induction factor

V0 Wind velocity at hub height

Vrel Resultant wind velocity

Blade designs to operate on either the principle of drag or lift. [3, 5]

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2.2.1 Drag Design

Drag force is the force parallel to the direction of the

oncoming airflow due both to viscous friction forces at the surface of

the blade and to unequal pressure on the blade surfaces facing toward

and away from the oncoming flow. For the drag design, the wind

pushes the blades out of the way. Drag-powered wind turbines

are characterized by slower rotational speeds and high torque

capabilities. They are useful for the pumping, sawing, or grinding work

that Dutch, farm, and similar "work-horse" windmills perform. For

example, a farm-type windmill must develop high torque at start-up to pump, or lift, water from a deep well.

2.1.2 Lift Design

Lift force is the force perpendicular to the direction of the

oncoming airflow as a consequence of the unequal pressure on the upper and lower surfaces of the blade. The lift

blade design to employs the same principle that enables airplanes, kites, and birds to fly. The blade is essentially an airfoil or wing. When air flows past the blade, a wind speed and pressure differential is created

between the upper and lower blade surfaces. The pressure at the lower surface is greater and thus acts to "lift"

the blade. When blades are attached to a central axis, like a wind turbine rotor, the lift is translated into

rotational motion. Lift-powered wind turbines have much higher rotational speeds than drag types and are therefore

well suited for electricity generation.

[3, 5]

Lift =

1

2

∗ ρ ∗ CL ∗ c ∗ L ∗ Vrel

2

(1)

Drag =

1

2

∗ ρ ∗ CD ∗ c ∗ L ∗ Vrel

2

(2)

Where

ρ – Density of Air – 1.225 kg/m3

C – Chord Length

L – Length of the blade element

Vrel – Relative velocity of air

Vrel = V0

2 + (rω)

2

(3)

III. Design Key Parameter

3.1 Wind Speed

This is very important to the productivity of a windmill. The wind turbine only generates power with the wind.

3.2 Site Selection

3.2.1 Location

By figuring out the direction from which the prevailing winds in selected areas usually come. It can be determined by observation during wind storms, and by looking at the trees near the site. Trees that are all leaning in the same direction and that have branches mostly on one side of the trunk are a good indication of prevailing wind speed and direction. Local airports and weather stations can sometimes provide this information.

3.1.2 Height Rotating a wind generator close to the ground is like mounting solar panels in the shade. At least the Wind generator should be located at least 30 feet above without any obstruction within 300 feet in any direction. Short towers in turbulent locations cause drastically reduced power output, and extreme physical stresses on the turbine and tower.

3.3 No of Blades & Blade Length The number of blades that make up a rotor and the total area they cover affect wind turbine performance. For a lift-type rotor to function effectively, the wind must flow smoothly over the blades. To avoid turbulence, spacing between blades should be great enough so that one blade will not encounter the disturbed, weaker airflow caused by the blade that passed before it. It is because of this requirement that most wind turbines have only two or three blades on their rotors. Blade length is considered as per design power output.

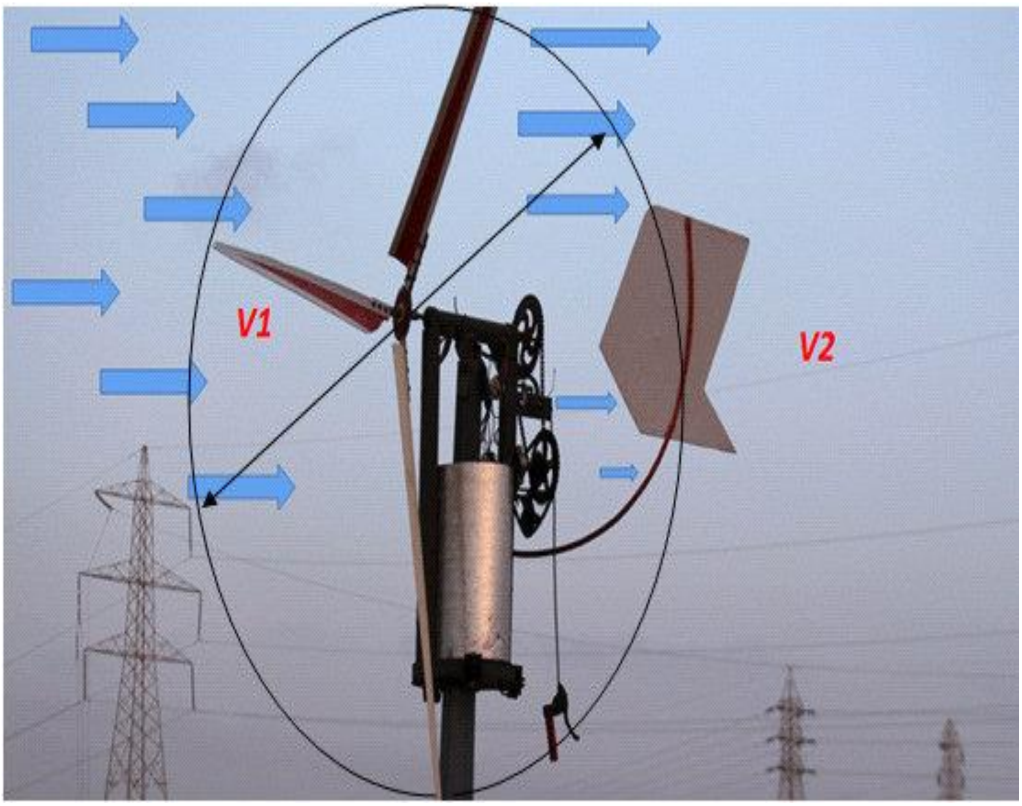
3.4 Tip Speed Ratio The tip speed is the ratio of the rotational speed of the blade to the wind speed. The larger this ratio, the faster the rotation of the wind turbine rotor at a given wind speed. Electricity generation requires high rotational speeds. Lift-type wind turbines have maximum tip-speed ratios of around 10, while drag-type ratios are approximately 1. Given the high rotational speed requirements of electrical generators, it is clear that the lift-type wind turbine is the most practical for this application.

3.5 Generators Different generator designs produce either alternating current (AC) or direct current (DC), and they are available in a large range of output power ratings. The generator's rating, or size, is dependent on the length of the wind turbine's blades because more energy is captured by longer blades. It is important to select the right type of generator to match your intended use. Most home and office appliances operate on 120-volt (or 240-volt), 50-cycle AC. Some appliances can operate on either AC or DC, such as light bulbs and resistance heaters, and many others can be adapted to run on DC. Storage systems using batteries store DC and usually are configured at voltages of between 12 volts and 120 volts. Generators that produce AC are generally equipped with features to produce the correct voltage (120 or 240 V) and constant frequency (60 cycles) of electricity, even when the wind speed is fluctuating. DC generators are normally used in battery charging applications and for operating DC appliances and machinery. They also can be used to produce AC electricity with the use of an inverter, which converts DC to AC.

3.6 Towers The tower on which a wind turbine is mounted is not just a support structure. It also raises the wind turbine so that its blades safely clear the ground and so it can reach the stronger winds at higher elevations. Maximum tower height is optional in most cases, except where zoning restrictions apply. The decision of what height tower to use will be based on the cost of taller towers versus the value of the increase in energy production resulting from their use. Studies have shown that the added cost of increasing tower height is often justified by the added power generated from the stronger winds. Larger wind turbines are usually mounted on towers ranging from 40 to 70 meters tall. Towers for small wind systems are generally "guyed" designs. This means that there are guy wires anchored to the ground on three or four sides of the tower to hold it erect. These towers cost less than freestanding towers but require more land area to anchor the guy wires. Some of these guyed towers are erected by tilting them up. This operation can be quickly accomplished using only a winch, with the turbine already mounted to the tower top. This simplifies not only installation but maintenance as well. Towers can be constructed of a simple tube, a wooden pole, or a lattice of tubes, rods, and angle iron. Large wind turbines may be mounted on lattice towers, tube towers, or guyed tilt-up towers. Installers can recommend the best type of tower for wind turbines. It must be strong enough to support the wind turbine and to sustain vibration, wind loading, and the overall weather elements for the lifetime of the wind turbine. Tower costs will vary widely as a function of design and height. Some wind turbines are sold complete with towers. More frequently, however, towers are sold separately

the pipe is then drawn in a straight line and measured on a round surface edge as shown in the Large sheet of paper is wrapped tightly to get a straight line around the pipe. With the paper wrapped around the pipe, we can mark the circumference. Then paper can be folded in half and marked halfway around the pipe. Then in half again and get quarters of the pipes. Cutting the pipe directly as per the marking can be possible. As With these methods, we should be able to draw good straight lines all over the pipe, dividing it lengthways into quarters. Now run the saw down the pipe to cut it in half. Like so & then again into quarters refer fig 5. Now for each four quarters, two things are required. Cut out a rectangle from the base so we can easily attach it to whatever we want to. Before you do the cut, drill a hole in the corner to improve the structural integrity of the material. Once the hole is drilled cut the rectangles out being careful not to cut past the hole. Cut from the high tip of the base to the point.

V. Final Product



Micro wind turbine project under study

VI. Field Testing & Calculation for Energy Output Kinetic energy in (joules) K. E = 1 2 ∗ m ∗ V 2 (4) Where: m = mass (kg) V = velocity (m/s) Note: In our area, we get average wind velocity is 3-8 m/sec. & humidity is 30% Usually, we're more interested in power (which changes from moment to moment) than energy. Since Energy = Power ∗ Time And density is a more convenient way to express the mass of flowing air; the kinetic energy equation can be converted into a flow equation. Power in the area swept by the wind turbine rotor :

P = 1 2 ∗ ρ ∗ A ∗ V 3 (6) Where: P = power in watts (746 watts = 1 hp) & (1,000 watts =1kilowatt) ρ = air density (about 1.225 kg/m3 at sea level, less high up) A = rotor swept area, exposed to the wind (m2) V = wind speed in m/s This yields the power in a free-flowing stream of wind. Of course, it is impossible to extract all the power from the wind because some flow must be maintained through the rotor (otherwise a brick wall would be a 100% efficient wind power extractor). So, we need to include some additional terms to get a practical equation for a wind turbine. Wind Turbine Power : P = 1 2 ∗ ρ ∗ A ∗ Cp ∗ V 3 ∗ Ng ∗ NB (7) Where: P = power in watts (746 watts = 1 hp) & (1,000 watts = 1 kilowatt) ρ = air density (about 1.225 kg/m3 at sea level, less high up) A = rotor swept area, exposed to the wind (m2) Cp = Coefficient of performance (.59 {Betz limit} is the maximum theoretically possible, .35 for a good design) V = wind speed in m/s Ng = generator efficiency (50% for car alternator, 80% or possibly more for a permanent magnet generator or grid-connected induction generator) Nb = gearbox/bearings efficiency (depends, could be as high as 95% if good) [4, 5] Tip Speed ratio for wind turbines is the ratio between the tangential speed of the tip of a blade and the actual velocity of the wind. λ = rω v (8) Where: λ= Tip speed ratio r= Radius of rotor v =wind velocity We can measure the wind velocity at different places by anemometer and Turbine velocity with the help of Non-contact type tachometer Now finally we consider the average velocity of wind is 8 m/sec. we get approx. power 300 W from equation (7) at velocity 8 m/sec. Here we take TSR = 4 & consider 3 blades wind turbine. The radius of the turbine is 1.02m. The average velocity of wind during various periods is given

This setup can easily achieve 120-200 RPM in a pretty average wind of 4 m/s. Calculating the wind turbine power without considering generator & gear box efficiency(7): P = 1 2 ∗ 1.225 ∗ π ∗ 1.022 ∗ 0.29 ∗ 8 3 P = 286.86 W We used a 100 V DC Motor (treadmill) for measuring O/P directly.

Results:

The results are taken on the basis that, 100 vehicles traveled at an average speed of 70 km/hr at a regular average wind speed of 4.5 m/s for the duration of 2hrs. The electric power generated from a designed wind turbine is approximately 200 watts –per hour.

Discussion:

Through case studies, this paper demonstrates a practical selection method for determining the optimum blade design parameters, that is, design wind speed, tip speed ratio, and

attack angle, for a fixed-pitch fixed-speed small wind turbine with a given baseline wind turbine and its blade airfoil. The conclusions and recommendations are as follows:

(1) the best design attack angle for a fixed-pitch fixed-speed wind turbine is not necessarily the angle with the maximum Cl/Cd. For the design case, the best attack angle is α0 = 5.5◦ even though the maximum/Cd appears at the attack angle α0 = 6.0◦;

(2) the design wind speed should be considered carefully for a baseline wind turbine with a fixed-pitch fixed-speed control strategy. If the design wind speed

is too low, the wind turbine rotor cannot achieve the expected rotor power output for the whole operating wind speed range. If the design wind speed is too high, the wind turbine rotor exceeds the rated power too much. For the design case, design wind speed Vdesign = 8 m/s exhibits the best performance for any site with an annual mean speed above 4.5 m/s;

(3) in terms of the design tip speed ratio for a fixed-pitch fixed-speed wind turbine, a low tip speed ratio is recommended when the annual mean wind speed is

low. However, a high tip speed ratio yields more energy when the annual mean wind speed is high. For the design case, λ0 = 5-6 should be considered if the

annual mean wind speed is between 5 m/s and 6 m/s;

Conclusions:

The main trend of wind turbine development is large-scale wind energy systems where annual average wind speed is high. On the other hand, a new branch of development in this field recently emerged. In regions of low wind speed and urban areas, small or micro wind turbines are more suitable. PVC-bladed wind turbines can be able to built by Laypersons, using readily available material that is feasible & affordable to provide much-needed electricity. PVC blade has much better power delivering capacity which can be able to propel at low wind speeds up to 2 m/s. Since most of the high wind power density regions in the zone of high wind speed are already being tapped by large-scale wind turbines and so it required creating a large scope for the development of low wind speed turbines.

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