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INNOVATIVE HYBRID POWER GENERATION ON NATIONAL HIGHWAYS

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Abstract-*Renewable energy sources i.e. energy generated from solar, wind, biomass, hydro power, geothermal and ocean resources are considered as a technological option for generating clean energy.But the energy generated fromsolar and wind is much less than the production by fossilfuels, however, electricity generation by utilizing PV cells and wind turbine increased rapidly in recent years. So many of researchers go through various topologies ofSolar-Wind hybrid Powergeneration system thatharnesses the renewable energies of Sun and Wind to generate electricity.This paper reviews the idea that we used here to generate electrical energy from Wind mill combined with solar tracking system. Here wind energy is utilized from wind pressure i.e produced due to the vehicle motion on highways. And solar energy is harnessed during day time by using smart solar tracking system to capture the maximum energy. The overall system control relies mainly on microcontroller. And it ensures the optimum utilization of resourcesand hence improves the efficiency as compared with theirindividual mode of generation. Also it increases the reliability and reduces the dependence on one single source. Hence with reference to hybrid topologies the detailed survey for proposed entitled work is carried out in this paper.*

Keywords--*Hybrid Energy, Wind Energy, Solar Energy, Smart Solar Tracking System, ATMEGA 328 Microcontroller, LM 7805,LM 7812.*

I. INTRODUCTION

We all know that the world is facing a major threat of fast depletion of the fossil fuel reserves. Most of the present energy demand is met by fossil and nuclear power plants. A small part is met by renewable energy technologies such as the wind, solar, biomass, geothermal etc. So there will soon be a time when we will face a severe fuel shortage. As per the law of conservation of energy, "Energy can neither be created, nor be destroyed, but it can only be converted from one form to another". Most of the research now is about how to conserve the energy and how to utilize the energy in a better way. Research has also been into the development of reliable and robust systems to harness energy from nonconventional energy resources.Among them, the wind and solar power sources have experienced a remarkably rapid growth in the past 10 years. According to an author in literature [1] for the last twenty years, solar energy and wind energy are the alternate and renewable resources that are available in plenty. Due to the use of renewable resources in recent years the advance materials and better manufacturing methods have decreased their capital costs making them more reliable and efficient. In hybrid system, wind turbine and photovoltaic cells, offer greater reliability than using them separately because the demand is not entirely based on one resource. For example, on a stormy day when solar energy is low there is likely enough wind energy available to compensate the lack of solar energy. In remote areas, where the grid connected power system does not exist, the stand alone system can be used to satisfy the power demand.Further studies provides us that Energy generation using solar photovoltaic requires large area. As cost of the land is growing day by day, there is a strong requirement to use the available land as efficiently as possible [10], which explored the potential of energy generation using the land above national road highways by constructing a roof structure. But as it is dependence on single source of renewable energy i.e Solar so it is not much reliable as solar energy is not available all the time. Also Wind energy sources are one of the highly available and reliable renewable energy resources. But discontinuous availability of wind energy makes a limitation on its utilization. This limitation can be removed by utilization of the area where wind flow is more [7], For this problem Highways are the better solutions. And further according to a research [6] [8],the integration of renewable energy sources and energy storage systems has been one of the new trends in power-electronic technology and the increasing number of renewable energy sources requires new strategies for their operations in order to maintain or improve the power supply stability, quality and reliability. There are some previous works on hybrid systems comprising of wind energy, photovoltaic and fuel cell have been discussed in [1]-[9]. In literature [1] a stand-alone renewable Hybrid Power Generation System presents the proposed design of a compact stand-alone hybrid power generation system using wind-solar resources. This system can be implemented in national highways where wind can be collected due to the high speed motion of vehicles and at the same time the solar energy from the ambient will also be

collected. Finally both energies will be acquired simultaneously for charging the batteries and is utilized for satisfying the electrical demands of domestic and rural areas. But this topology uses the fixed solar system so it can not completely harness the availability of solar energy. Further in a research paper [2], a hybrid generation system implemented with a vertical axis wind turbines (VAWT), is proposed to be placed on the medians therefore fluid flow from both sides of the highway will be considered in the design and existing streetlights on the medians can be fitted to the system.However 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.

In this paper on the reference of various researches [1]-[10], In our proposed model we have changed the position and direction of wind turbine to be placed. We have implemented the wind turbine just above the highwayon a horizontal shaft (in horizontal direction) attached to the base model provided with two DC generators at each side of the turbine. In addition, we have also attached a solar panel above it provided with a smart solar tracking system. This tracking will increase the efficiency of solar panels to trap maximum radiation from the sun. And the overall obtained energy is stored in a battery that provides the most advantageous operation in the solar and wind power systems i.e maintenance free dry type and utilizes the special electrolytes. These batteries provide a perfect performance for long discharges [6]. The proposed system has some advantages such as the energy generated can be utilized not only by street lights but also in traffic signal, direction& distance indicators and microgrid.

Ⅱ. PROPOSED SCHEME

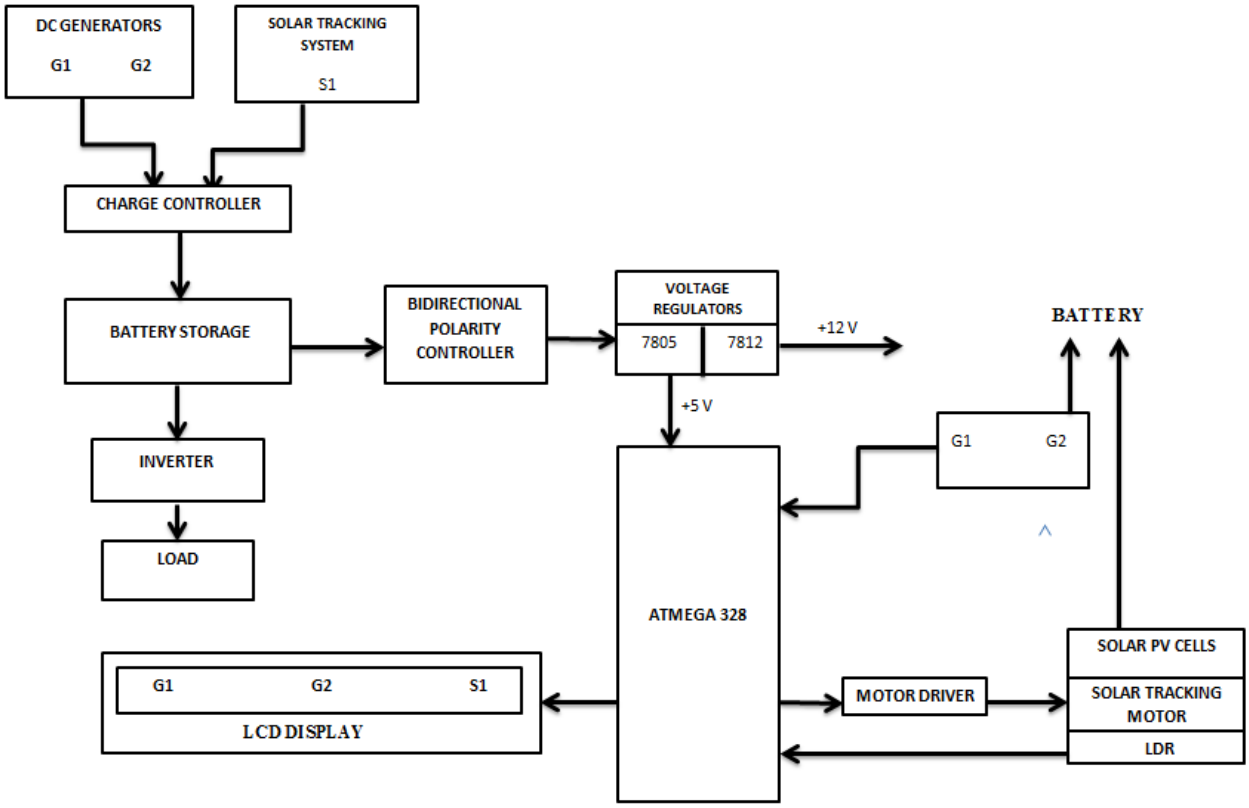


Fig.1 Block Diagram

Fig1 shows the block diagram of proposed model of our Hybrid generation system. In which in order to harness the wind energy DC Generators are used and for solar energy solar tracking system is provided and the integration of both energy is given to the storage system through charge controller. The overall control scheme mainly relies on ATMEGA328 µc.

A.Wind Power Generation:-

Wind turbine with two dc generators as shown in fig.1 placed just above the road having support on two extreme ends. As on highways vehicles run only in one direction along its particular lane, So these wind turbines are having blades specially designed for unidirectional rotation opposite to the vehicles motion.

B.Smart Solar Tracking System:-

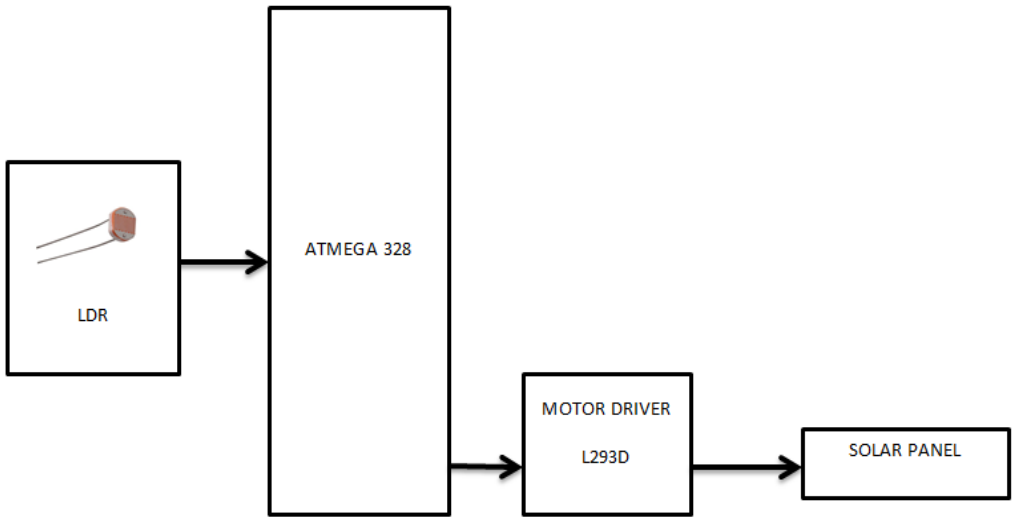


Fig.2Smart Solar Tracking System

The fig.2 shown above shows the Single Axis Tracking System,in which single axis tracker with one degree of freedom follows the sun's movement from east to west during daytime.The control algorithm are executed in a ATMEGA328 µc .The light dependent resistors (LDR) are utilized to sense the sun's position and a feedback error signal was then generated to the control system to continuously monitor the maximum solar radiation on the pv panel.The LDR that is used in it is a resistor whose resistance decreases with increasing incident light intensity, and this information is then passed to the light comparison unit.The output from the light comparison unit comes to the input of the microcontroller which determines the direction of the movement of the motor with the help of motor driver L293D (used for conversion of binary into mechanical data) in both direction so as a result the sun's beam or radiation maintain to remain aligned with the solar panel.

C. ATMEGA-328 µc:-

The Atmel ATMEGA328 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications.AVR family has a GCC based IDE that is free for whole range of their processors. AVR is an 8-bit CPU and on the same clock it is 4 times faster then 8-bit PIC and 12 times faster then 8051. ARM is 32-bit, so this family µc are more powerful and much more power hungry. However AVR familyµc consumes less power and provides greater battery life. So in our Hybrid generation system we used this this µc

D. Voltage Regulators:-

Voltage regulator is used to regulate voltage level. When a steady, reliable voltage is needed, then voltage regulator is the preferred device. It generates a fixed output voltage that remains constant for any changes in an input voltage or load conditions. It acts as a buffer for protecting components from damages.Most common voltage regulator is of series 78xx (sometimes L78xx, LM78xx,MC78xx..) which is a family of self-contained fixed linear voltage regulator integrated circuit.

E. Batteries :-

The batteries in the system provide to store the electricity that is generated from the Hybrid energy system. Any required capacity can be obtained by serial or parallel connections of the batteries. It is connected to the the bidirectional polarity controller for its protection and implemented with solar tracking system in order to provide operation of the tracker.

F. Inverter:-

Energy stored in the battery is drawn by electrical loads through the inverter, which converts DC power into AC power. The inverter has in-built protection for Short-Circuit; Reverse Polarity, Low Battery Voltage and Over Load.

Ⅲ. SYSTEM DESIGN

A. Design of Wind Energy Generator:-

In the case of designing or choosing the blade, the diameter of the wind-rotor is very important. And the energy produced by wind turbines depends on the swept area of the blades.So as the swept area of the rotor increases, the area it covers also increases with the square of the radius. Thus, doubling the length of a turbines blades results in an increase of four times its area which allows it to receive four times as much wind energy. The shapes of the blades are important near the tip but much less than near to the root (the larger, inner end of the blade). However It can convert only up to 25 -35% of the wind pressure to make a mechanical movement with blades.[6]

The equation describes the mechanical power captured from wind by a wind turbine [4] can be formulated as,

$$P_m = {}^1/_2 \times \rho \times A \times (V)^3 \times C_p$$

Where:

$$\rho = Air\ density\ in\ K_G/m^3$$

A= Swept area in m^3

C_p= Power coefficient of the wind turbine

V= Wind speed in m/s

Theoretical maximum value of the power coefficient C_P is 0.59. It is dependent on two variables, the tip speed ratio (TSR) and the pitch angle. The pitch angle refers to the angle in which the turbine blades are aligned with respect to its longitudinal axis. *TSR* is defined as the linear speed of the rotor to the wind speed.[6]

$TSR = \lambda = \frac{\omega R}{V}$

Where:

ω= Turbine rotor speed (rad/s)

R= Radius of the turbine blade (m)

v = Wind speed (m/s)

B.Power Generated by the Solar Panel:-

The global formula for calculation of the solar energy obtained from solar panel is given by,

$$E = A \times \epsilon \times H \times PR$$

Where,

E = Energy (kWh)

A = Total solar panel Area (m2)

ϵ = solar panel yield or efficiency(%)

H = Annual average solar radiation on tilted panels (shadings not included)

PR = Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75)

$'\epsilon'$isthe yield of the solar panel given by the ratio : electrical power (in kWp) of one solar panel divided by the area of one panel.

Example : the solar panel yield of a PV module of 250 Wp with an area of 1.6 m2 is 15.6%.

Be aware that this nominal ratio is given for standard test conditions (STC) : radiation=1000 W/m2, cell temperature=25 celcius degree, Wind speed=1 m/s, AM=1.5.

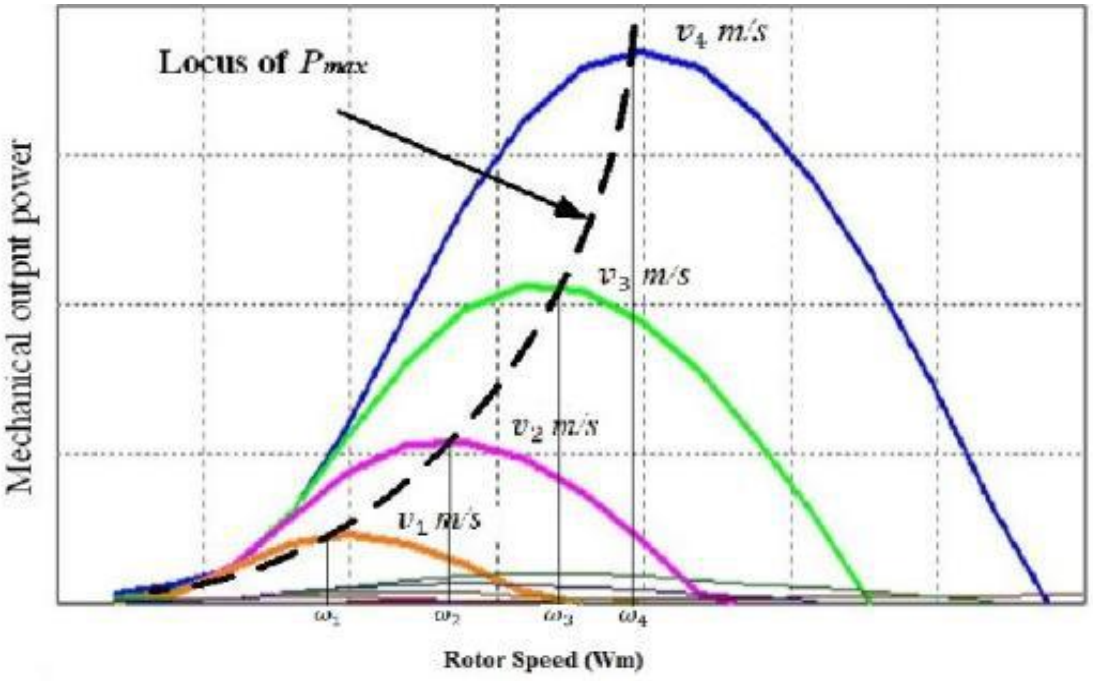
The unit of the nominal power of the photovoltaic panel in these conditions is called "Watt-peak" (Wp or kWp=1000 Wp orMWp=1000000 Wp).

'H' is the annual average solar radiation on tilted panels.

We have to find the global annual irradiation incident on our PV panels with specific inclination (slope, tilt) and orientation .

'PR' : PR (Performance Ratio) is a very important value to evaluate the quality of a photovoltaic installation because it gives the performance of the installation independently of the orientation, inclination of the panel.

Ⅳ. PERFORMANCE ANALYSIS



Graph1.Mechanical power o/p versusgenerator speed at differentwind speed.

Graph.1 as shown clearifies the output power of a wind turbine versus rotor speed, while wind speed is changed from V_1 to V_4 (V_4>V_3>V_2>V_1). Fig. 3 shows that if speed is v1, at rotor speed ω1 maximum power could be captured. While speed increases from V_1 to V_4, similar to the maximum power point tracking rotor speed is also increases from ω_1 toω_4. The maximum power line indicates the peak power obtained from the turbine motion.

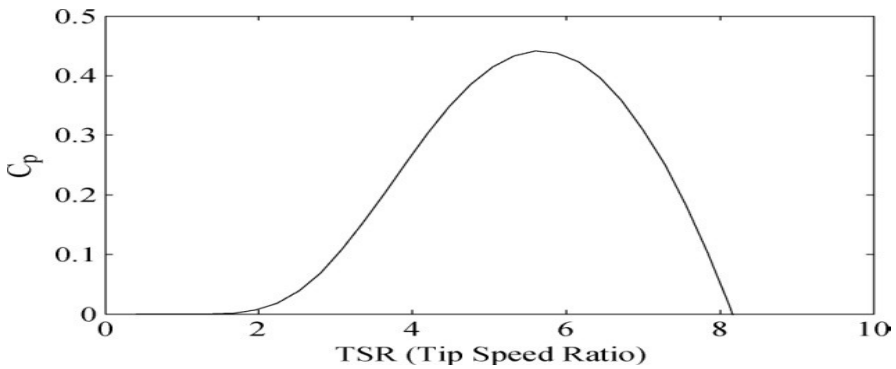
Efficiency of system:-

Efficiency is a function of how fast the rotor tip rotates for a given wind speed producing a constant wind speed to tip ratio called the "tip-speed ratio" (λ) which is a dimensionless unit used to maximise the rotor efficiency. A good wind turbine design will determine the rotor power for any combination of wind and rotor speed. The larger this ratio, the faster the rotation of the wind turbine rotor at a given wind speed. The shaft speed that the rotor is fixed too is given in revolutions per minute (rpm) and depends on the tip-speed and the diameter of the turbines blades.

Above equation of the RPM can be given as ,

$RPM=V\times \lambda \times \pi D$

The number of blades also plays a vital role in the speed developed by the rotor, multi-blade has low tip ratio it creates a high torque but power does not increase. The speed should be more than the torque to generate electricity.



Graph 2.Coefficientof Performance (cp) versus tip speed ratio (λ) for wind turbine.

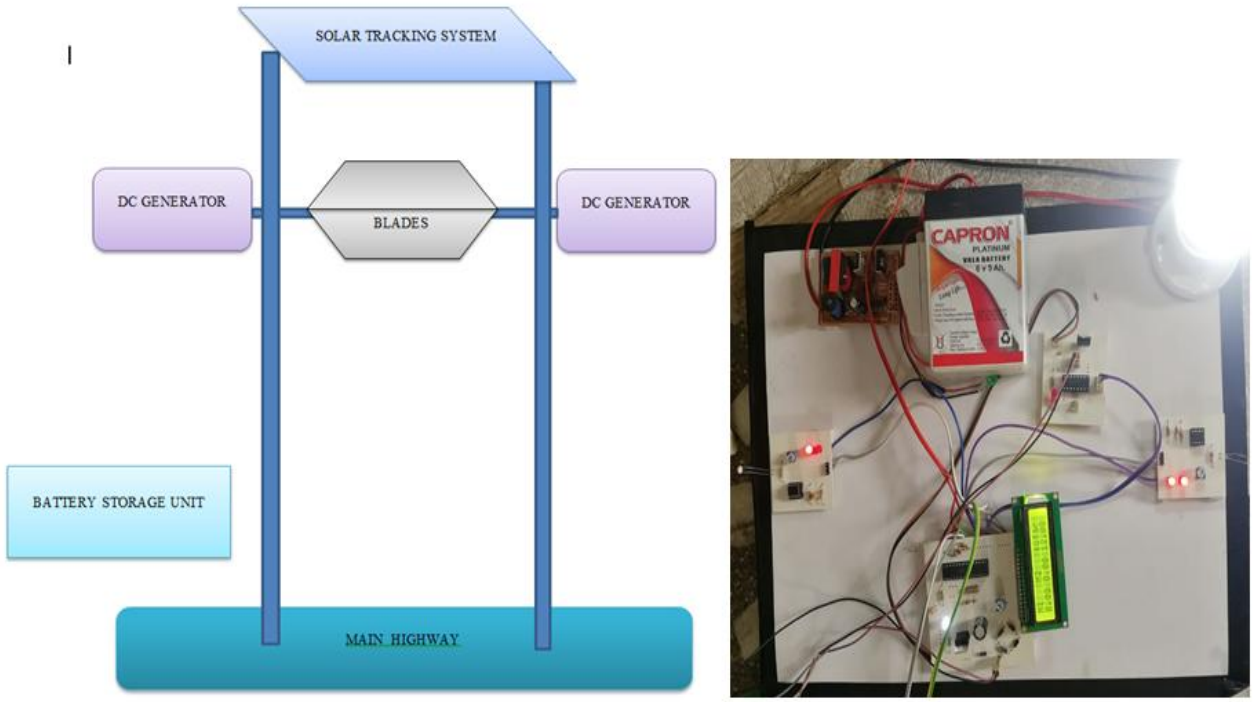


Fig.3 Actual Model with Control Circuit

V. SYSTEM SCOPE

***A. Advantages*:-**

- A long life cycle since it can provide power for more than 20-25 years
- Zero operation cost, because it does not consume fuel or materials.
- Maintenance cost is low.
- Energy conservation.
- Keep the environment clean and away from pollution of the CO2 emissions in atmosphere.

***B. Limitations*:-**

- Influenced due to random changing of air density
- Requires proper investigation for site selection
- Problems of facing lack of vehicles sometimes

C. Applications :-

- On national highways to supply power
- In remote areas with proper storage
- In rural electrification
- To recharge battery of electrical vehicle
- In traffic signaling system
- Off grid applications

V.CONCLUSION

Finally we can conclude that this project of hybrid power generation helps to avoids the use of non-renewable resources contributing towards their longer usage. For installing it on highways, it requires extensive data collection on wind patterns produced by vehicles on both sides of the highway. Using the collected data, a wind turbine is designed to be placed above the highway. Also, the integration of solar tracking system with special arrangement of the wind turbine blades will increase the efficiency of the overall system and also avoids interruption of the power flow. As the model use two generators at a time, greater output can be obtained from the wind turbine and during the summers the solar panels designed with tracking system will produce their peak outputs.

Also as a future scope this work can be extended to trains and metro as the speed is high as compared with on road vehicles. And in future we can make use of Vortex bladeless a radical new way to generate wind energy.

VI. FUTURE SCOPE

Our project idea can be extended to trains and metro trains as their speed is very high as compared with on road vehicles.This stored energy can be further utilised for agricultural fields and rural electrification. And ,also as a future scope we can use Vortex blades in the form of a new radical way to generate wind energy.

Further, with other improvements overall efficiency of model can be increased by using piezo-electric material in place of blades of wind turbine, setting turbines near tunnels ,etc.

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