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Electricity Generation using Hybrid Solar Wind-Energy Tower

G.S.Dhumal[1], Koustubh Salunkhe[2], Dhiraj Salunke[3],Lalit Sonawane[4], Akash Sohani [5]

[1](Asst. Prof., Mechanical Engineering, JSPM Narhe Technical Campus, Pune, Maharastra, India.)
[2,3,4,5](B E Students, Mechanical Engineering, JSPM Narhe Technical Campus, Pune, Maharastra, India.)

Abstract: *The objective of the project 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 velocity of the wind 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 consist 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 source of power. 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.*

I. Introduction

Renewable energy is generally electricity supplied from sources, such as wind power, solar power, geothermal energy, hydropower and various forms of biomass. These sources have been coined renewable due to their continuous replenishment and availability for use over and over again. The popularity of renewable energy has experienced a significant upsurge in recent times due to the exhaustion of conventional power generation methods and increasing realization of its adverse effects on the environment Facts from the World Wind Energy. Association estimates that by 2010, 160GW of wind power capacity is expected to be installed worldwide which implies an anticipated net growth rate of more than 21% per Year.

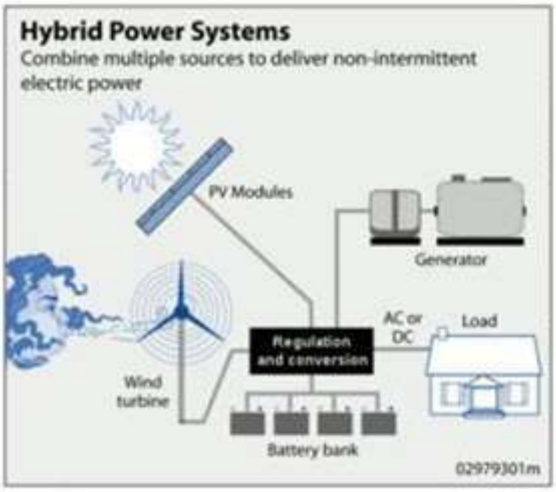


Fig 1. Hybrid Power System

This project focuses on the utilization of wind energy as a renewable source. The aim of this major qualifying project is to design and implement a magnetically levitated vertical axis wind turbine system that has the ability to operate in both high and low wind speed conditions. Our choice for this model is to showcase its efficiency in varying wind conditions as compared to the traditional horizontal axis wind turbine and contribute to its steady growing popularity for the purpose of mass utilization in the near future as a reliable source of power generation. Unlike the traditional horizontal axis wind turbine, this design is levitated via maglev (magnetic levitation) vertically on a rotor shaft.

This maglev technology, which will be looked at in great detail, serves as an efficient replacement for ball bearings used on the conventional wind turbine and is usually implemented with permanent magnets. This levitation will be used between the rotating shaft of the turbine blades and the base of the whole wind turbine system. The conceptual design also entails the usage of spiral shaped blades and with continuing effective research into the functioning of sails in varying wind speeds and other factors, an efficient shape and size will be Electricity Generation using Hybrid Solar Wind-Energy Tower determined for a suitable turbine blade for the project With the appropriate mechanisms in place, we expect to harness enough wind for power generation by way of an axial flux generator built from permanent magnets and copper coils. The arrangement of the magnets will cultivate an effective magnetic field and the copper coils will facilitate voltage capture due to the changing magnetic field. The varying output voltage obtained at this juncture will then be passed through a DC-DC converter to achieve a steady output DC voltage.

II. Feature

□ Hybrid system [Solar + Maglev System] By using this system power output increases by 30% to 60%. It is

possible to align the system.

- Solar Tracking system
- By using this system we can generate electric

ity in remote areas. The energy availability is free of cost.

□ Street Light ON

-OFF Reasonable control of the light distribution It has no high temperature effect Battery Charging Multiple batteries can be charged Deep cycle lead acid batteries have been employed in renewable energy storage.

III. Theoretical Study

II.1 Maglev system?

Maglev (derived from magnetic levitation), is a system of transportation that suspends, guides and propels vehicles, predominantly trains, using magnetic levitation from a very large number of magnets for lift and propulsion. This method has the potential to be faster, quieter and smoother than wheeled mass transit systems. The power needed for levitation is usually not a particularly large percentage of the overall consumption; most of the power used is needed to overcome air drag as with any other high speed train.

One such technology is Magnetic Levitation, or Maglev, which has the promise of becoming the largest development in transportation since the wheel. As a matter of fact, Maglev does away with the wheel and all the problems inherent with it (friction, noise, energy use, safety, and so forth) by using magnetism to levitate a vehicle above a track and to move it from one place to another. The greatest advantage to this is the absence of friction. Since Maglev vehicles float above tracks instead of riding on wheels, the vehicles do not come into contact with the track or roadbed; thus, they eliminate friction.

Transportation systems that use Maglev have been implemented in airports for ground transportation and in major metropolitan cities for light rail systems. In selecting the vertical axis concept for the wind turbine that is implemented as the power generation portion of this project, certain uniqueness corresponded to it that did not pertain to the other wind turbine designs. The characteristic that set this wind generator apart from the others is that it is fully supported and rotates about a vertical axis. This axis is vertically oriented through the center of the wind sails, which allows for a different type of rotational support rather than the conventional ball bearing system found in horizontal wind turbine.

This support is called maglev, which is based on magnetic levitation. Maglev offers a near frictionless substitute for ball bearings with little to no maintenance. The four different classes are Alnico, Ceramic, Samarium Cobalt and Neodymium Iron Boron also known is the most recent addition to this commercial list of materials and at room temperature exhibits the highest properties of all of the magnetic materials very attractive magnetic characteristic, which offers high flux density operation and the ability to resist demagnetization. This attribute will be very important because the load that will be levitated will be heavy and rotating high speeds, which will exhibit a large downward force on the axis. The next factor that needs to be considered is the shape and size of the magnet which is directly related to the placement of the magnets. It seems that levitation would be most effective directly on the central axis line where, under an evenly distributed load, the wind turbine center of mass will be found.

IV. Principles of Magnetic Levitation

Magnetic materials and systems are able to attract or press each other apart or together with a force dependent on the magnetic field and the area of the magnets. For example, the simplest example of lift would be a simple dipole magnet positioned in the magnetic fields of another dipole magnet.

During this process, the vehicle is placed on a track with alternating north and south polarity magnets.

Electrical current passes through a coil of wire that touches the magnet, thus creating an electromagnet. Reversing the electrical current changes the polarity of each electromagnet.

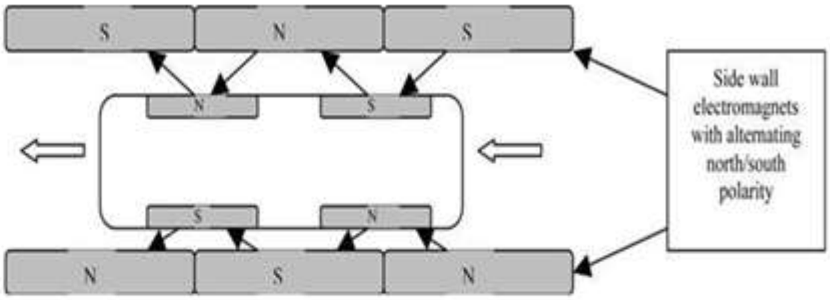


Fig.2 Principles of Magnetic Levitation

IV. 1 Overview and Working

This section introduces and provides a brief description of the major components and factors that will contribute to an efficiently functioning wind turbine. These factors are wind power, the generator,magnet levitation and the DC-DC converter. Later sections will provide an in-depth look into the essence of each factor and its function and importance to the overall operation of the vertical axis wind turbine.

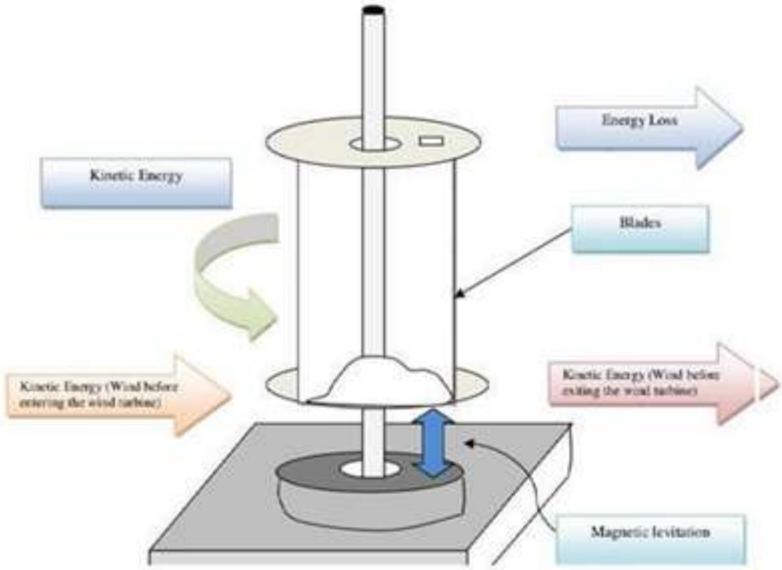


Fig.3 Vertical Axis Wind Turbine

IV. 2 Magnetic Selection

Some factors need to be assessed in choosing the permanent magnet selection that would be best to implement the maglev portion of the design. Understanding the characteristics of magnet materials and the different assortment of sizes, shapes and materials is critical. There are four classes of commercialized magnets used today which are based on their material composition each having their own magnetic properties.

The four different classes are Alnico, Ceramic, Samarium Cobalt and Neodymium Iron Boron also known Nd- Fe-B. Nd-Fe-B is the most recent addition to this commercial list of materials and at room temperature exhibits the highest properties of all of the magnetic materials. It can be seen in the B-H graph that Nd-Fe-B has a very attractive magnetic characteristic which offers high flux density operation and the ability to resist demagnetization.

This attribute will be very important because the load that willevitated will be heavy and rotating a high speeds which will exhibit a large downward force on the axis The next factor that needs to be considered is the shape and size of the magnet which is directly related to the placement of the magnets. It seems that levitation would be most effective directly on the central axis line where, under an evenly distributed load, the wind turbine center of mass will shows a basic rendition of how the maglev will be integrated into the design. If the magnets where ring shaped then they could easily be slid tandem down the shaft with the like poles facing toward each other. This would enable the repelling force required to support the weight and force of the wind turbine and minimize the amount of magnets needed to complete the concept. Electricity Generation using Hybrid Solar Wind-Energy Tower The permanent magnets that were chosen for this application were the N42 magnets. These are Nd-Fe-B ring shaped permanent magnets that are nickel plated to strengthen and protect the magnet itself. The dimensions for the magnets are reasonable with an outside diameter of 40mm, inside diameter of 20mm and height of 10mm.

VI. 3 Solar Tracking System

Solar energy is very important means of expanding renewable energy resources. In this paper is described the design and construction of a microcontroller based solar panel tracking system. Solar is a nonconventional source of energy, considering this we have developed solar panels so that we can fulfill our electricity need. But due to revolution of the earth, solar source i.e. sun does not face the panel continuously hence less electricity is produced.

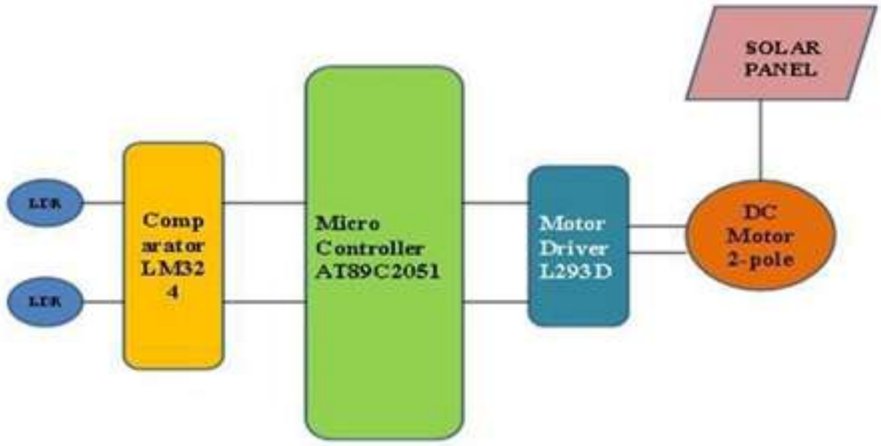


Fig.4 Block Diagram Of Solar Tracking System

The energy panel should face the SUN till it is present in a day. The problem above can be solved by our system by automatic tracking the solar energy. The block diagram below shows system architecture it consist of a LDR sensor senses max solar power which is being given to the Microcontroller through the ADC which digitizes the LDR output. Controller then takes the decision according to then algorithm and tilts the panel towards the direction of the max energy given by LDR with the help of DC Motor . The Motor is used to rotate the LDR to sense the max solar power. A Solar Tracker is basically a device onto which solar panels are fitted which tracks the motion of the sun across the sky ensuring that the maximum amount of sunlight strikes the panels throughout the day. After finding the sunlight, the tracker will try to navigate through the path ensuring the best sunlight is detected. It is completely automatic and keeps the panel in front of sun until that is visible.

Its active sensors constantly monitor the sunlight and rotate the panel towards the direction where the intensity of sunlight is maximum. Residential that uses solar power as their alternative power supply will bring benefits to them. The main objective of this project is to development of an automatic solar tracking system whereby the system will caused solar panels will keep aligned with the Sunlight in order to maximize in harvesting solar power. The system focuses on the controller design whereby it will caused the system is able to tracks the maximum intensity of Sunlight is hit. When the intensity of Sunlight is decreasing, this system automatically changes its direction to get maximum intensity of Sunlight. LDR light detector acts as a sensor is used to trace the coordinate of the Sunlight by detecting brightness level of Sunlight. While to rotate the appropriate position of the panel, a DC geared motor is used.

The system is controlled by two relays as a DC-geared motor driver and a microcontroller as a main processor. This project is covered for a single axis and is designed for low power and residential usage applications. From the hardware testing, the system is able to track and follow the Sunlight intensity in order to get maximum solar power at the output regardless motor speed.

VI.3.1 Overview and Working Principle of Solar Tracking system

Figure shown here is the tracking device in out prototype. It is the one which follows the sun's movement throughout the day and provides uninterrupted reflection to the solar panel. The sun rays will fall on the solar panel in two ways, which is, they will fall directly on the solar panel and also the reflector will reflect the incident rays on the solar panel. Suppose at the time of sun rise the sun is in extreme east the reflector will align itself in some position by which the incident rays will fall on the solar panel.

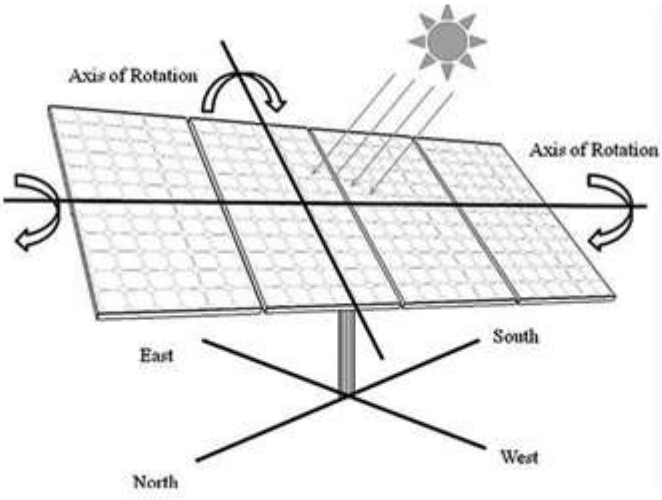


Fig.5 A Axis of rotation

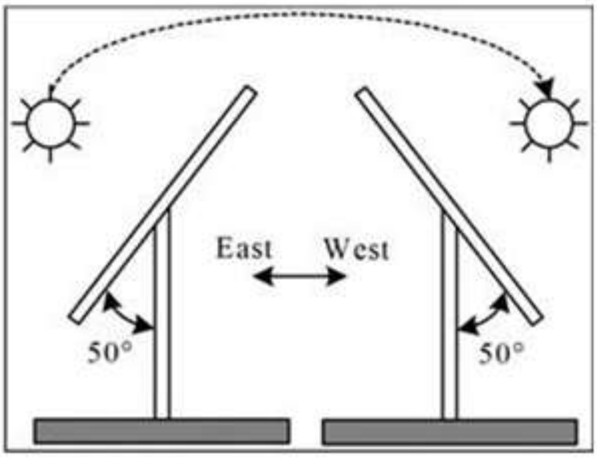


Fig.6 B Axis of Rotation

Now when the earth rotates and the sun gets shifted from its earlier position the reflection of the incident rays will also change. Thus as a result the light will fall on the sensors kept on each side of the solar panel.

The tracking circuit is so designed that when reflection falls on say the sensor attached to the right of the panel, the tracker will move towards the left, and visa-versa. Similar is the case when the reflection falls on the sensor attached at the top of the panel, circuit will make the tracker to move downwards. We here have tried to bring two simple principles together. One being, the normal principle of incidence and reflection on which our tracker works. And the other is the principle on which the solar panel works, which is on the incidence of the solar rays the photovoltaic cells, will produce electricity. This both principles are combined there and as a result of which we are able to fetch nearly double the output which the panel gives normally. Precisely speaking the tracker is liable for two kinds of rotations, on is on the vertical axis and other is on the horizontal axis. The earlier is for the right-left movement of the reflection and the latter is for the up-down movement of the reflector, for aligning reflection on the panel.

V. Design

Due to noise issue for small- and medium-size wind turbines, which are generally installed close to properties, the wind turbine blade tip speed should not exceed 70 m/s. For variable-speed machines, a high blade

tip speed, such as between 65 m/s and 70 m/s, is normally considered, so as to achieve high rotor power coefficient CPR and wind turbine power performance. However, for fixed-speed machines, we should address the blade tip speed carefully. Consider the operation wind speed from 3 m/s to 20 m/s and define the blade tip speed 68 m/s, then the tip speed ratio λ in the operation wind speed range varies from 22.667 to 3.4. This basically means at low wind speed, such as at 5 m/s, λ = 13.6, the rotor power coefficient CPR will be very low [8]. If we define blade tip speed 40 m/s, then the tip speed ratio λ in the operation wind speed range varies from 13.333 to 2. Then at wind speed 5 m/s, λ = 8, which is likely to exhibit much better performance for sites with low annual mean wind speed. Therefore, let us first consider three blade tip speeds 40 m/s, 50 m/s, and 60 m/s, which correspond to rotor speeds 84.883 rpm, 106.103 rpm, and 127.324 rpm, respectively
. Re = 400000
Airfoil and Design Attack Angle. The airfoil used for the baseline wind turbine is DU93W210. The airfoil performance is affected by Reynolds number, which is defined by

Re = ρUL

Where, in terms of wind turbine airfoil, ρ is the air density, μ is the air viscosity, U is the relative wind velocity, and L is the chord length of the airfoil. Generally, the Reynolds number of each blade section is not exactly the same. By means of estimation using the method provided by Singh et al, the Reynolds number of each blade section is between 3×105−5×105 for this wind type turbine. To simplify the design process, we choose the Reynolds number 4 × 105 as the design Reynolds number. The aerodynamic performance of DU93W210 airfoil at different Reynolds numbers can be calculated using XFoil software, which is widely used to design and analyze airfoils .The maximum lift/drag ratio is Cl/Cd = 88.72 at attack angle α0 = 6.0◦. For the design cases, we offset one design attack angle on both side of the attack angle αº = 6.0º with maximum lift/drag ratio, with a step of 0.5º in between, and the three design attack angles are α = 5.5º, α = 6.0º, and α = 6.5º.[1]

Therefore, the maximum theoretical efficiency has yet to be achieved. Over the centuries many types of design have emerged, and some of the more distinguishable are listed in Table 2. The earliest designs, Persian windmills, utilized drag by means of sails made from wood and cloth. These Persian windmills were principally similar to their modern counterpart the Savories rotor (No. 1) which can be seen in use today in ventilation cowls and rotating advertising signs. Similar in principle is the cup type differential drag rotor (No. 2), utilized today by anemometers for calculating airspeed due to their ease of calibration and multidirectional operation.

The American farm windmill (No. 3) is an early example of a high torque lift driven rotor with a high degree of solidity, still in use today for water pumping applications. The Dutch windmill (No. 4) is another example of an early lift type device utilized for grinding corn which has now disappeared from mainstream use, yet a small number still survive as tourist attractions. The Darrius VAWT (No. 5) is a modern aerodynamic aero foil blade design which despite extensive research and development has so far been unable to compete with the modern HAWT design, although recent developments could see a resurgence of this rotor type. [1]

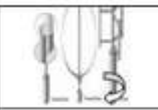
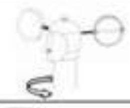
1	Savonius rotor	VAWT	Historic Persian windmill to modern day ventilation	Drag	16%	
2	Cup	VAWT	Modern day cup anemometer	Drag	8%	
3	American farm windmill	HAWT	18th century to present day, farm use for Pumping water, grinding wheat, generating electricity	Lift	31%	
4	Dutch Windmill	HAWT	16th Century, used for grinding wheat.	Lift	27%	
5	Darrieus Rotor (egg beater)	VAWT	20th century, electricity generation	Lift	40%	

Table.1. Modern and historical rotor designs.

V.1 Power Calculation

Under constant acceleration, the kinetic energy of an object having mass (m) and velocity (v) is equal to the work done (W) in displacing that object from rest to a distance s under a force (F), i.e.:

$E = W = Fs$
According to Newton's Law, we have:
$2F = ma$
Hence,
$E = mas$ …………………………………….. (1)
Using the third equation of motion:
$v^2 = u^2+2as$
We get,
a = $(v^2- u^2)2$ Since the initial velocity of the object is zero, i.e. u = 0, we get:
a = $^2/2$
Substituting it in equation (1), we get that the kinetic energy of a mass in motions is:
E = $1/2(mv^2)$……………………………………….…(2)
The power in the wind is given by the rate of change of energy:
P= / = $1/2V^2$ / ………………………………… (3)
A mass flow rate given by:
/ =ρA(/)
and the rate of change of distance is given by:
/ =V
We get:
/ = ρAV
Hence, from equation (3), the power can be defined as:
P = $1/2\rho Av^3$……………………………………. (4)

A German physicist Albert Betz concluded in 1919 that no wind turbine can convert more than16/27 (59.3%) of the kinetic energy of the wind into mechanical energy turning a rotor. To this day, this is known as the Betz Limitor Betz' Law.The theoretical maximum power efficiencyof any design of wind turbine is 0.59 (i.e. no more than 59% of the energy carried by the wind can be extracted by a wind turbine). This is called the" power coefficient" and is defined as[22]
$C_{pmax}=0.59$
Also, wind turbines cannot operate at this maximum limit. The Cpvalue is unique to each turbine type and is a function of wind speed that the turbine is operating in. Once we incorporate various engineering requirements of a wind turbine - strength and durability in particular – the real world limit is well below the Betz Limit with values of 0.35-0.45 common even in the best designed wind turbines. By the time we take into account the other factors in a complete wind turbine system - e.g. the gearbox, bearings, generator and so on - only 10-30% of the power of the wind is ever actually converted into usable electricity. Hence, the power coefficient needs to be factored in equation (4) and the extractable power from the wind is given by[22]
$P_{avail}=1/2\ \rho\ Av3$……………..………..……....(5)

The swept area of the turbine can be calculated from the length of the turbine blades using the equation for the area of a circle:

A = πDL -………………………………....(6)

We are given the following data:

Blade length, l = 0.075 m
Wind speed, v = 3 m/sec
Air density, ρ = 1.23 kg/m3
Power Coefficient, Cp= 0.4
Inserting the value for blade length as the radius of the swept area:

A= πDL -
= π*0.3*0.45 - π*0.15*0.45
=0.212 m2
We can then calculate the power converted from the wind into rotational energy in the turbine using equation (5):

Power = 1 /2ρAv3cp

= 0.5*1.23*0.212*(3)^3*0.4 **Power** = 1.5Watt

Diameter(m)	**Area** (m2)	**Density(**kg/m 3)	**Cp**	**Velocity(m/s)**	**Speed(rpm)**	**Power (W)**
0.3	0.212	1.23	0.4	3	190.986	1.50
0.3	0.212	1.23	0.4	4	254.648	3.34
0.3	0.212	1.23	0.4	5	318.302	6.52
0.3	0.212	1.23	0.4	6	381.963	11.26
0.3	0.212	1.23	0.4	7	445.623	17.89
0.3	0.212	1.23	0.4	8	509.284	26.70
0.3	0.212	1.23	0.4	9	572.945	38.02
0.3	0.212	1.23	0.4	10	636.605	52.15
0.3	0.212	1.23	0.4	11	700.265	69.41

Table 2. Theoretical Calculation of Power

VI. Conclusion

1) Hybrid power generation system is good and effective solution for power generation than conventional energy resources.
2) It has greater efficiency.
3) It can provide to remote places where government is unable to reach. So that the power can be utilize where it generated so that it will reduce the transmission losses and cost.
4) Cost reduction can be done by increasing the production of the equipment.
5) People should motivate to use the non conventional energy resources.
6) It is highly safe for the environment as it doesn't produce any emission and harmful waste product like conventional energy resources.
7) It is cost effective solution for generation.
8) It only need initial investment.
9) It has also long life span.
10) Overall it good, reliable and affordable solution for electricity generation.

References

[1]. Christoph Maurer, Christoph Cappel, Tilmann E. Kuhn "Progress in buildingintegrated solar systems" (March 2018)

[2]. DoganEryener, HilmiKuscu "Hybrid transpired solar collector updraft tower" (Jan 2018)

[3]. S.Y. Li, M. Liu, H.X. Li, Y. Hui , Z.Q. Chen S.Y. Li "Effects of structural damping on wind-induced responses of a 243-meter-high solar tower based on a novel elastic test model" (Dec 2017)

[4]. Sunanda Sinha, S.S. Chandel "Prospects of solar photovoltaic–micro-wind based hybrid power systems" (Oct 2017)

[5]. Yong Yang, Su Guo, Deyou Liu, Rong Li, "Yinghao Chu, Operation optimization strategy for wind-concentrated solar power hybrid power generation system" (April 2017)

[6]. Mohamed E. Abdallah, Osama M. Arafa, Adel Shalto, Ghada A. Abdel Aziz "Wind turbine emulation using permanent magnet synchronous motor (Nov 2016)

[7]. QunwuHuang ,Yeqiang Shi, Yiping Wang , Linping Lu , Yong Cui "Multi-turbine wind-solar hybrid system" (May 2016)

[8]. E.E. Vogel , G. Saravia , S. Kobe , R. Schumann , R. Schuster "A method to optimize electricity generation from wind energy" (Feb 2016)

[9]. Md Nor Musaa, KaharOsmana, Ab Malik A. Hamat "Renewable Energy from Induced Airflow Generated by Cruising Ground Vehicles in Tandem using RANS"(Sept 2015)

[10]. Zeyu Liu, Yuying Yan, Rong Fu, Mustafa Alsaady "Enhancement of solar energy collection with magnetic nanofluids(March 2015)

[11]. HuoyueXianga, , YongleLia, SurenChenb, GuangyangHoub "Wind loads of moving vehicle on bridge with solid wind barrier"(2014)

[12]. Oscar López-Lapeña , Ramon Pallas-Areny "Solar energy radiation measurement with a low–power solar energy harvester"(2013)