RESEARCH ARTICLE

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Wind Turbine Erection, Installation, Commissioning and Analysis for An Educational Institute

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ABSTRACT

For the development of sustainable energy system, nowadays a variety of systems are available. Traditionally diesel generators were used as a backup source to power failure of existing Grid. With Technological advancement in renewable energy sources, such as solar and wind, we can make use of this freely available energy as a backup source to charge a battery and in turn utilize it, during power failure or on regular basis. This paper presents erection of a small wind turbine with a capacity of 1.5 KW. It has been installed on the terrace of an engineering college located in Maharashtra state. The wind turbine is successfully installed and observations are taken on a daily basis. These observations are analyzed in detail for checking the availability of the Wind and power extraction from the horizontal Axis wind turbine. The load connected is the light load including fans, tubes, personal computers, printers etc. It has been found that a small wind turbine with a capacity of 1.5 KW can charge the battery system especially when sun is not available but the wind is at a reasonable speed. An enclosed HAWT gives a very good performance and maintenance free operation. It can generate energy at a wind speed of 4 m/s. Excellent results have been found during light wind conditions also. The NACA design of the blades responds to moderate wind speed due to its aerodynamic design. It has been also noticed that as compared to the combination of other Renewable Sources available, solar and wind is the best possible combination considering the availability, financial investment and performance parameters.

Keywords: HAWT Horizontal axis wind turbine, Power curve , NACA design.

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INTRODUCTION

The renewable energy source is one of the best option for generation of electricity They are sustainable and environmental friendly[1].The biggest disadvantage with the usage of conventional resources is that their usage causes pollution due to the production of various pollutants like ash in case of a coal power plant, smoke in case of diesel power plant, radioactive material in case of nuclear power plant.[2] More specifically, wind and solar are complements for each other throughout the year. In the educational institute mentioned in this paper, a complete hybrid wind-solar off grid system is installed. The main focus of the paper is on installation, erection and commissioning of only wind energy source.

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Figure 1: Wind-Solar Hybrid system

Figure 1 depicts the actual photograph of the installed wind energy system erected on the rooftop of the institute. Horizontal axis wind turbine with capacity of 1.5 KW is installed and utilized with combination of Solar power in offgrid mode. The hybrid inverter is used with rating of 7.5 KVA. The priority is set as Solar-Battery(Wind)-Grid. The battery of 12 V, 220AH has been utilized. Ten such batteries are connected in series to match the system voltage of 120 Volts. The separate Wind controller has been installed to charge the batteries through power generated by the wind energy source .

Design, Erection and Installation of Wind Turbine

The Wind turbine stated in this paper is Whisper make with fully enclosed structure. This design is best suited for small capacity urban applications. This has low maintenance and has dust free, light weight blades. This turbine responds to a minimum wind speed of 3.5 m/sec& starts generating power at 4 m/sec.

Site Selection

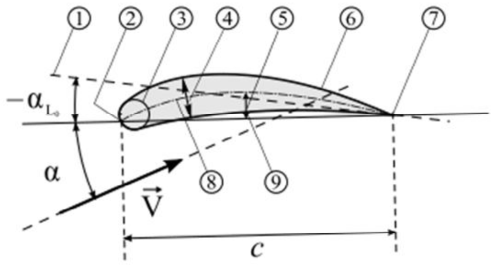
For selection of the wind site, many important facts should be considered. Some of the major attribute includes,

- Superior wind speed
- Good road access to sites
- Suitable geology for onsite access
- Low population density
- Minimum risk of agroforestry for operations
- Close to suitable electrical grid for ON grid system.
- Supportive landholders
- Privately owned free hold land
- Good industrial support for construction and ongoing operation
- Significant potential for revalidation

Design factors of Wind turbine

Following are important parts of the wind turbine with respect to erection and installation of the wind turbine.

- Diameter of rotor
- Number of blades
- Blade profile
- Blade chord length
- Setting angle
- Height of tower
- Transmission system
- Gearbox



1: Zero-lift line; 2: Leading edge; 3: Nose circle; 4: Max. thickness; 5: Camber; 6: Upper surface; 7: Trailing tip; 8: Camber mean-line; 9: Lower surface

Figure 2: Rotor Blade design

Blade design is the most important aspect which maximizes the lift and minimizes the drag. Following are the important features of the blade design depicted in figure 2.

- The wind velocity is constant throughout the rotor area but the blade velocity increases from inner edge to the tip
- The lifting force developed at the tip is higher than that of inner edge therefore tip tries to move faster than central part. This produces a stress that causes the blade failure.
- The tension developed at the inner side due to centrifugal force is more than tip.
- Both these problems can be minimized by designing a tapering blade. So that the blade area at the tip is smaller than the inner edge.

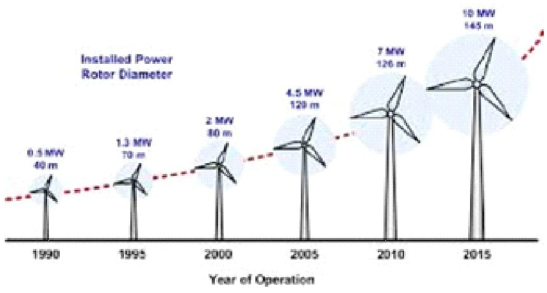


Figure 3: Tower height and capacity

Figure 3 shows the relationship between capacity of the wind turbine and corresponding tower height. The tower is installed in different sections. In the installed system, discussed in this paper, tower height is of thirty feet with three sections of ten feet each.Speed of electrical generator is much higher than speed of wind turbine. Therefore gearbox is inserted in transmission system. As wind speed varies from low to high, the gear ratio is also not fixed and needs to be varied to get maximum efficiency for a constant speed wind turbine fixed gear ratio is set. For variable speed wind turbine a better overall efficiency may be obtained with two speed gearbox. It switches from low gear ratio to high gear ratio at low wind speed. Wind speed increases with height. Higher towers also raise generators above the air turbulence that can exist close to the ground.[3]

Characteristics of Wind turbine

Horizontal axis wind turbine has to be oriented to face the wind. In low and moderate wind speed, the aim is to capture the maximum possible power. Whereas during high winds the main aim is to protect the generator and the power electronic equipment from overloading by limiting the turbine power to the rated value. At gust speed the machine has to be stalled. Stalling is the process of purposeful stopping of the machine[4]. The minimum wind speed at which the wind turbine produces its designated output power is called as rated wind speed For Most of the turbines the speed is 9 and 16m/s. High rotor efficiency is desirable for increased wind energy extraction and should be maximized within the limits of affordable production. Energy carried by moving air is expressed as a sum of its kinetic energy.

The power generated is given by P

$P = (½)\rho AV^3$………………………..   (I)

where

ρ is air density,

A is swept area and

V is air velocity

The magnitude of energy harnessed is a function of the reduction in air speed over the turbine[5].

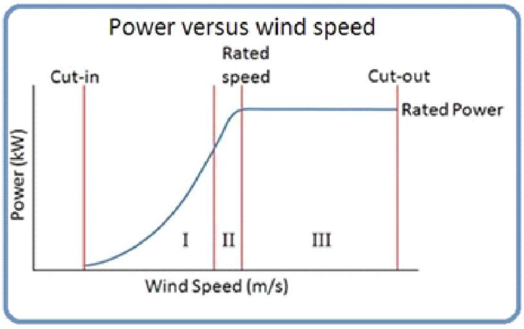


Figure 4: Speed power Characteristics of Wind turbine

Figure 4 shows zone II and III where the turbine is operated by the controller. Zone I shows the rotation of the turbine blades but negligible power generation. At cutout speed , the turbine is shifted to stalling mode[5] by the controller.

Relative Wind velocity = Wind velocity – Blade Velocity

Tip Speed Ratio TSR: It is the relationship between rotor blade velocity and relative wind velocity. The following equation is the foremost design parameter around which all other optimum rotor dimensions are calculated[6].

$= \Omega r/V_w$………………………………(II)

Where λ = Tip Speed Ratio

Ω = Rotational Velocity (rad/s)

r = Radius

Vw = Wind Speed

Assembling of Wind turbine

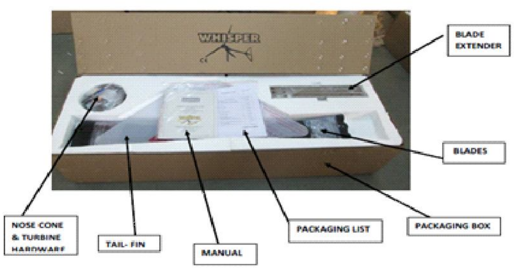


Figure 5 : Wind turbine assembling [3]

Figure 5 shows the main components needed to assemble the turbine on site. Figure 6 depicts the heart of the system means wind controller and the wind generator.

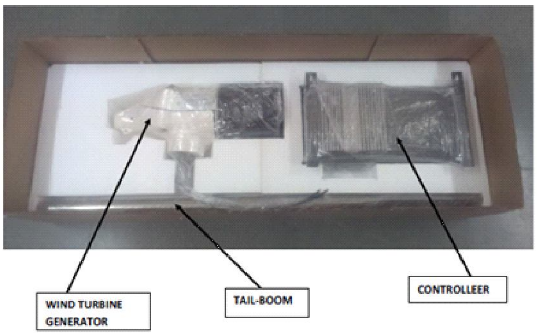


Figure 6 : Wind turbine controller [3]

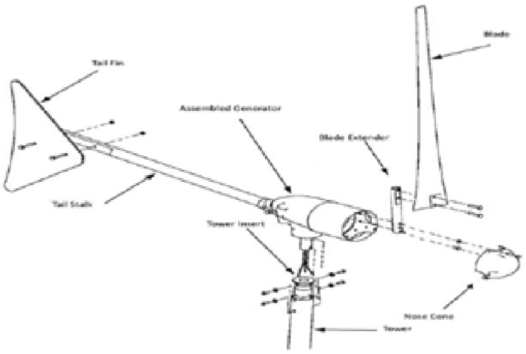


Figure 7 : Wind turbine assembling.[3] (WS1500 Manual pg.19)

As shown in figure 7, all parts are assembled in co-axial way before the erection of the tower. The alignment of blades and tail are very important to maintain balance and distribution of centrifugal forces [7].

Figure 7 shows the mounting of turbine on the tower before erection. All the parts of tower are first assembled tightly with the help of nut bolt arrangement. The cement foundation is also prepared seven days in advance before the erection. The whole tower is erected and aligned on the cement foundation.

Figure 8 shows the mounting of turbine with the tower. There is an engagement hole to fix the turbine on the tower. This arrangement is in such a way that yaw control can be achieved to get the direction of the wind.(WS1500 Manual pg.20)

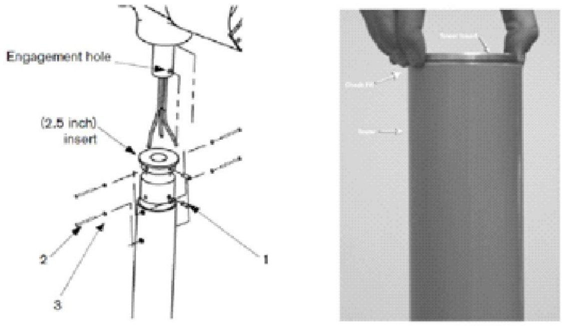


Figure 8: Mountingof turbine with the tower.[3]

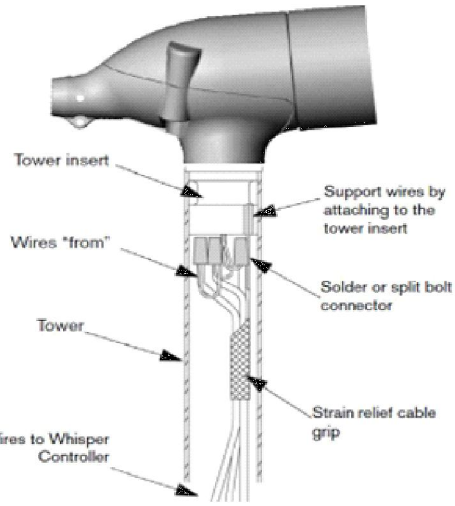


Figure 9: Wiring of windturbine[3]

Figure 9.[3](WS1500 Manual pg.22) shows the wiring details of turbine contacts with the cables. These cables are trenched in a conduit and further connected to the wind controller. The electrical output of this turbine charges the tubular batteries in the setup to met the load requirements. Following are some of the safety instructions for making the connections.

1) Solder or use split bolts to make electrical Connections.
2) Wrap connections thoroughly with Electrical tape to Prevent shorts to tower.
3) Support wires to avoid weight on Slip ring wires and Wire connections.

The wind tower is supported with four or eight guy wires for additional safety. Guy wires are the supporting wires which are firmly stretched between the tower and cement foundation at all the four sides. In case of any accidental cause, these four wires will create tension in all the four sides in such a way that the tower will not fall down and no harm will be provided to the people at the site location.

There is a facility of braking the turbine with artificial brakes. All the three phases are shorted to provide brake. This arrangement is essential before installation. Once all installation along with the controller and load is over, brake is released and the turbine starts it's operation.

WIND CONTROLLER

Figure 10 shows the back panel and mountings of wind controller and Figure 11 Shows the connection details of the controller used. Three phases are connected to W1 terminals which is the turbine output.[3] The controller uses the power generated by the turbine to charge the batteries. It has the provision to display the instantaneous power, and current generated by the turbine along with the cumulative power generated since the installation. On connecting the anemometer to the controller the wind speed is also displayed.

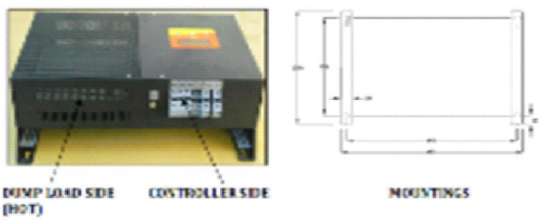


Figure 10: Wind Controller[3]

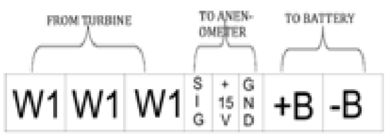


Figure 11: Connection diagram of wind controller[3]

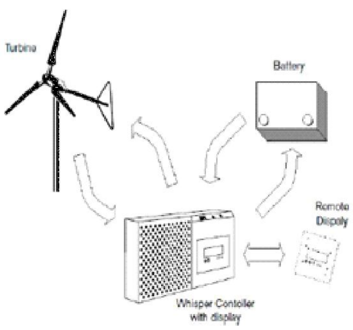


Figure 12: Controller interconnected devices[3]

Figure 12 Controller interconnected devices[3] focuses on interconnected system with controller. It is connected to three phase wind turbine with rated output power of 1.5 KW. As the wind is intermittent the power generation will takes place as per the availability of wind. Controller will charge the batteries. Dump load arrangement is provided so as to dump the generated power if battery is fully charged and demanded power is less than the generated power.[3]

BATTERY SYSTEM

As per the system voltage selection, Total 10 batteries are connected in series to match the voltage range of 120V. Each rating of battery is 12V, 220Ahr.

OBSERVATIONS

Table 1 depicts the observations taken on the installed set up for the generated wind energy.

Table-1: Observation Table

Date of Observation	Wind speed (m/sec)	Cumulative Wind energy generation in KWhr
2/8/21	6	8.165
4/8/21	5	9.756
5/8/21	4.8	11.135
6/8/21	6	11.926
7/8/21	5	12.297
9/8/21	4	12.430
10/8/21	4	12.506
11/8/21	6	12.586
12/8/21	6	12.662
17/8/21	2	13.035
18/8/21	4	13.041
20/8/21	3	13.196

It is been observed that the turbine starts rotating and takes the direction of wind at the speed of around 3.5m/s and starts to generate the power at the speed of 4m/s. The power generated during August and September 2021 was observed on a daily basis and used for analyzing the system.It has been also observed that daily average energy of about 700 Whr is generated as per the availability of the wind at the mentioned site. The priority of the Hybrid system is maintained as Solar-Wind-Grid.

Figure 12 shows the generation of the wind energy from the installed wind turbine on daily basis in the month of August 2021.It has been noticed that average 700 Whr energy is generated on daily basis even when the moderate wind speed of about 4-5 m/s was present.

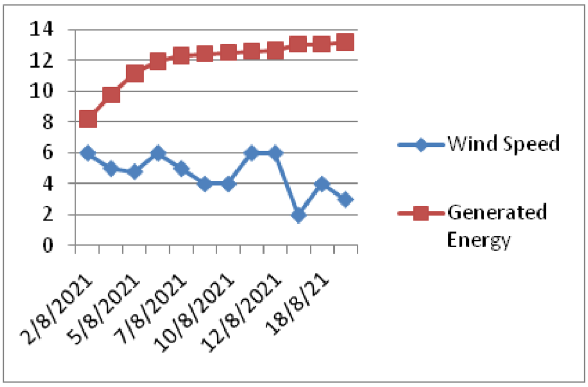


Figure 12: Daily energy generated and wind speed

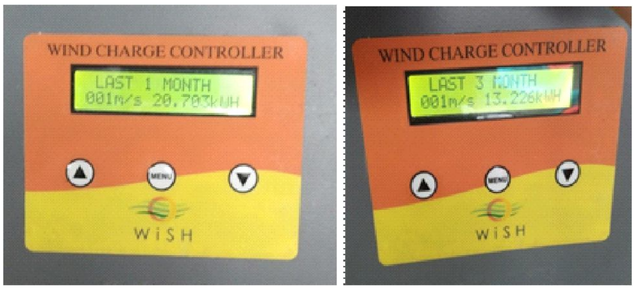


Figure 13: Photograph of Actual readings from controller

Figure 13 shows the actual photographs of the reading observed from the wind controller on monthly basis. The readings are cumulative.

Conclusion

As per the data observed it can be concluded that the even in urban areas good amount of power is generated using wind energy. The power generated by wind plays an important role of charging the battery system in absence of solar power, especially during days and nights in monsoon. In places where grid is not available, the solar wind hybrid system is definitely a good option. From the erected hybrid system at the mentioned educational institute, it is observed and analyzed that, wind and solar in hybrid system are complementary sources to each other. Battery bank can be charged in absence of solar energy during monsoons using the windmill and is extremely vital to support the load completely on renewable sources. Only wind energy is not sufficient to fulfill the load demand and also pay back period of Wind energy system is very high. Throughout the year, the energy can be generated and utilized at the own premises from Solar, wind hybrid combination. As seen from the observation table around thirteen units were generated in the month of August using only wind energy. Overall electricity bill can be reduced at a considerable extend and reliability can be maintained. The 8 to 10 KVA system can be installed on rooftop of an educational system and considering the life span of about 25 years, it is the best possible option. The overall payback period of the system is about 7-8 years. The erected and installed hybrid system provides practical approach to the students for learning various fundamental concepts and important terminologies with respect to renewable energy systems.

References

[1] KhagendraBahadurThapa, ArbinMaharjan ETAL," Paper Modelling of Wind Solar Hybrid Power System for Off Grid in Nepal and A Case Study" October 2020Journal of the Institute of Engineering 15(3):360-367 DOI:10.3126/jie.v15i3.32223

[2] Bharat Raj Singh, Bal Krishna Dubey, "SOLAR-WIND HYBRID POWER GENERATION SYSTEM"International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 01 | Jan-2018e-ISSN: 2395-0056 p-ISSN: 2395-0072

[3] WS1500-"Wind generation system", owner's manual for Installation, operation and maintenance, Wish energy systems pvt. Ltd.

[4] A book on Small wind turbine specifications,design and economics, JacubBakula,KrzysztofDamaziak, published July 27th 2016 DOI:10.5772/62821

[5] WIT Transactions on State of the Art in Science and Engineering, Vol 44, © 2010 WIT Press doi:10.2495/978-1-84564-205-1/07

[6] Richard J Crossley 1,Peter J. Schubel 2 "Wind Turbine Blade Design"ISSN 1996-1073 Published 6 September 2012.

[7] WindPACT Turbine Design Scaling Studies Technical Area Self-Erecting Tower and Nacelle Feasibility March 2000 March 2001.