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A Review on Roof Top Wind Turbine Design and Applications

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Abstract- In present work an approach is made to design a hwat for roof top application to fulfill the requirement of a urban household. For achieving the cut-off speed the bernaulies theorem is applied by using convergent and divergent duct. Is this NACA-0012 profile is selected for wind turbine blade. This work is consist of two steps of work in first step wind turbine blade is designed by using different correlations and in second step duct with single diffuser and double diffuser are analyze and duct with vertex generator is also examines to optimize the design of duct. The site selection for the input parameter is the shriram institute of technology Jabalpur (mp). The result obtain are compared with the base research paper reviewed. And the result represents the sustainable power production from design.

Keywords- NACA-0012, household etc.

I. INTRODUCTION

1. Renewable Energy:

In present scenario, the demand for electricity in India has been increasing due to the increase in population and economic development of the country. As technology has advanced in certain areas the ability to produce power has had to keep pace with the ever increasing demands.

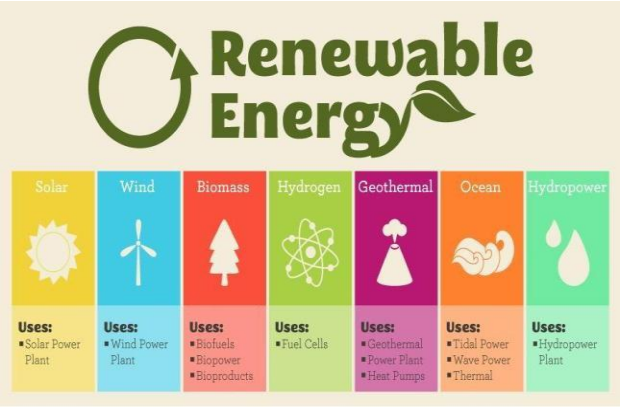

Fig 1. Types of renewable energy.

There always seems to be energy-crisis whether contrived or real, and society allows the pollution of our environment in the name of power production. Power production with traditional means has polluted our planet.

Any sort of fossil fuel powered plant releases carbon dioxide and other pollutants into the environment during the combustion process. With the pollution grown to an alarming level, the whole world is rapidly shifting to more clean and green source of energy.

Renewable energy is energy that is collected from renewable resources, which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat and all the renewable sources of energy are sustainable. Sustainable Energy is one which is able to meet the growing demand of today's people without compromising the demand of the people that would require it in future. Renewable energy often provides energy in four important areas: electricity generation, air and water heating/cooling, transportation, and rural (off-grid) energy services.

The major renewable sources of energy in India are wind, solar, water, geothermal energy, and biomass. Among the major sources, hydropower is most exploited and solar and wind energy is the developing energy sources. The sustainable and renewable nature of these energy resources is the reason for rapid development in the renewable energy technology.

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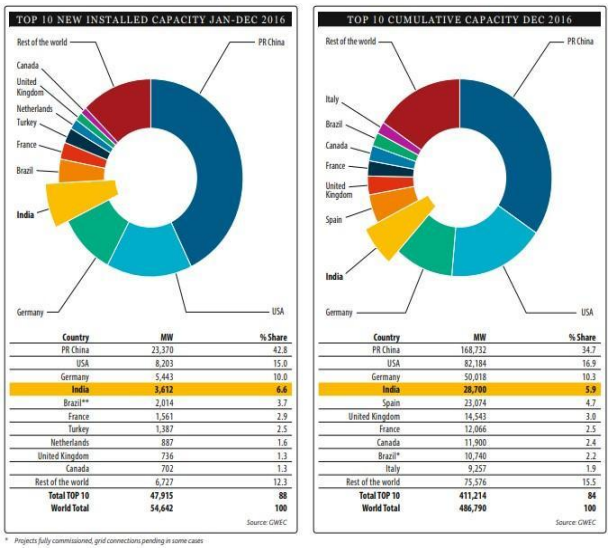
2. Wind Energy:

Wind occurs owing to differences in temperature of air warmed by the sun. Warmer air rises, whereas colder air sinks. This circulation produces wind. The energy of wind, i.e. "wind power," increases in proportion to the cube of wind speed.

Since wind is produced by the Sun and air, it is an inexhaustible resource. The energy of the wind on the land surface of the Earth is estimated to be four times annual global energy demand, and if the wind-blown on the oceans are included, this figure reaches more than 10 times global energy demand. When wind turbines are rotated by the wind, they convert wind energy into electricity.

2.1 Current Scenario:



Country	MW	% Share
PR China	23,370	42.8
USA	8,203	15.0
Germany	5,443	10.0
India	**3,612**	**6.6**
Brazil**	2,014	3.7
France	1,561	2.9
Turkey	1,387	2.5
Netherlands	887	1.6
United Kingdom	736	1.3
Canada	702	1.3
Rest of the world	6,727	12.3
Total TOP 10	**47,915**	**88**
World Total	**54,642**	**100**

Source: GWEC

Country	MW	% Share
PR China	168,732	34.7
USA	82,184	16.9
Germany	50,018	10.3
India	**28,700**	**5.9**
Spain	23,074	4.7
United Kingdom	14,543	3.0
France	12,066	2.5
Canada	11,900	2.4
Brazil*	10,740	2.2
Italy	9,257	1.9
Rest of the world	75,576	15.5
Total TOP 10	**411,214**	**84**
World Total	**486,790**	**100**

Source: GWEC

* Projects fully commissioned, grid connections pending in some cases

Fig 2. Current scenario of the world in Wind Energy.

Wind power generation capacity in India has significantly increased in recent years. Wind power accounts nearly 9.87% of India's total installed power generation capacity and generated 46,011million KWh in the fiscal year 2016-17 which is nearly 3% of total electricity generation According to the report India's well-developed wind power industry has the capability and experience to help meet the country's climate and energy security goals. Today India is the 4th largest wind market globally, with total installations having crossed the 31GW mark at the end of March 2017. The industry is firmly on track to meet the short-term national target of 60GW by 2022's.

The wind energy is an environment-friendly and efficient source of renewable energy. The kinetic energy of the wind can be used to do work. This energy is harnessed by windmill in the past to do mechanical work. This is used for water lifting pump and generating electricity. To generate the electricity, the rotary motion of, the windmill is used to turn the turbine of the electric generator. The output of single windmill is quite small and cannot be used for commercial purposes. Therefore, a number of windmills are erected over a large area, which is known as wind energy farm. The each and every windmill is coupled together to get a electricity for commercial purposes.

A wind turbine is a device that converts the winds kinetic energy into electrical energy. The wind turbine has added a provider of useful mechanical power for the last thousand years has been authoritatively established. The wind turbine is also describing as a wind energy conversion system (WECS) or, if used to produce electric power, as a wind turbine generator (WTG).

2.2 Why wind energy?

- The project is environment friendly.
- India has good wind potential to harness wind energy.
- A permanent shield against ever increasing power prices. The cost per kwh reduces over a period of time as against rising cost for conventional power projects.
- The cheapest source of electrical energy. (on a levelled cost over 20 years.)
- Least equity participation required, as well as low cost debt is easily available to wind energy projects.
- A project with the fastest payback period.
- A real fast track power project, with the lowest gestation period; and a modular concept.
- Operation and Maintenance (O&M) costs are low.
- No marketing risks, as the product is electrical energy.
- A project with no investment in manpower.

A country like India or any region where energy production is based on imported coal or oil will become more self-sufficient by using alternatives such as wind power. Electricity produced from the wind produces no CO_2 emissions and therefore does not contribute to the greenhouse effect. Wind energy is relatively labour intensive and thus creates many jobs. In remote areas or areas with a weak grid, wind energy can be used for charging batteries or can be combined with a diesel engine to save fuel

whenever wind is available. At windy sites the price of electricity, measured in Rs/kWh, is competitive with the production price from more conventional methods, for example coal fired power plants.

2.3 Fundamentals of Wind Energy:

2.1.1 Wind Energy: Wind is caused by flow of air from high pressure area to low pressure area and this difference in pressure is result of heating of the uneven earth's surface by sun. So we can say that wind energy is a form of solar energy.

2.1.2 Wind power: Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electrical power, windmills for mechanical power and wind pumps for water pumping.

2.1.3 Wind Turbine: A turbine is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. A turbine is a turbo-machine with at least one moving part called a rotor assembly, which is a shaft with blades attached. Moving fluid acts on the blades so that they move and impart rotational energy to the rotor. A wind turbine is a device that converts kinetic energy from the wind into electrical power.

II. LITERATURE REVIEW

Improving the Value of the Power Coefficient for Three Straight-Blades Darrieus Wind Turbine by Farhan A Khammas et al 2021 In this study, an experimental test was carried out using a subsonic wind tunnel to study the improvement of the power coefficient of the three straight-blade Darrieus vertical axis wind turbine. A three-blade vane type vertical axis wind turbine with three movable vanes in each of the blades was fitted in the middle of the three straight-blade Darrieus (0012 Airfoil) vertical axis wind turbine and they are installed on the same rotor shaft. For this purpose, two vertical axis wind turbine, the first one has three straight-blades Darrieus of type 0012 Airfoil and the second also has three straight-blade Darrieus but of type 0012 Airfoil with a three-blade vane type vertical axis wind turbine with three movable vanes were manufactured. Both turbines were tested using a subsonic wind tunnel at different wind speeds ranging from (4-28) m/s. The consequences showed that in the second turbine test, a power coefficient of Cp=0.39 was obtained, which is greater than the power coefficient of the first turbine (Cp =0.184) after the turbines were tested in a wind tunnel under identical conditions at a wind speed of 6 m/s. Therefore, the second wind turbine produces greater electrical power than the first wind turbine.

Concept design and numerical analysis of hybrid solar–wind turbine by K S Ackshaya Varshini et al 2021 A wind turbine is a device that converts wind energy to electrical energy. External factors such as wind speed and direction shift, as well as turbine blade design considerations, cause a significant amount of energy to be wasted throughout the conversion process. Considering all these losses, a turbine's average efficiency is roughly 45 percent. The blades of a wind turbine are one of the most crucial factors in determining the turbine's efficiency. The design and geometry of the blades have a direct impact on performance since it determines how much kinetic energy from the wind is converted into mechanical energy. Many concepts and technologies are being used to improve the efficiency of wind turbines while lowering their maintenance costs. Wind turbines based on their axis orientation are classified as vertical axis and horizontal axis.

Vertical axis wind turbines are not as widespread as their horizontal-axis counterparts due to their lower efficiency. In this study, we will use a Savonius vertical axis wind turbine to investigate a way of enhancing its efficiency by installing solar panels on its vertical blades and determining the best performance angle at which the turbine should be kept achieving maximum efficiency. Computation fluid dynamic analysis and thermal and structural analysis has been performed to check the efficiency of the designed blade. As a result, an optimized wind turbine design has been developed.

3. Performance optimization of a dual-rotor ducted wind turbine by using response surface method Javad Taghinezhad a, Reza Alimardan et al 2021 The presented study evaluates and optimizes the performance of dual-rotor wind turbines installed inside a developed duct. The effect of different operating conditions on the extracted power was compared between dual rotor wind turbines (DRWT) and single rotor wind turbines (SRWT). These operating conditions include the type of dual-rotor wind turbines installed in the throat section of the duct, the distance between the two rotors of a turbine, and the flow velocity through the

duct throat that were evaluated by the multivariate statistical method response surface methodology. The central composite design of the response surface method was utilized to fit the designed model based on the least-squares method.

Also, the multiple regression method was applied for the empirical data to match variable operating conditions with the developed model by analysis of variance (ANOVA). Afterward, some experiments were carried on to validate this method. The results showed a maximum power ratio of about 55% at the optimized conditions for dual rotor wind turbines. Determined P-values for designed parameters of models were less than 0.05, which makes its effect on the model significant. Furthermore, the power ratio obtained from empirical data was compatible with the considered model.

4. Active power control strategy of wind farm considering fatigue loadof wind turbines Jie Zhaoa, Yudi Fanga,∗, Yuqin Hea ET AL…… 2021

For the purpose of maximize the utilization of wind energy and reduce the generation cost of wind farms, an active power control strategy of wind farm considering the fatigue load intensity of wind turbines was proposed. Turbulence intensity, average wind speed and active power command were used to evaluate the comprehensive fatigue load strength of the wind turbine. Then an improved particle swarm optimization algorithm was applied to optimize the active power distribution of each wind turbine, which maximize wind energy capture and keep the fatigue load intensity of each wind turbine within a certain allowable range.

The effectiveness is proved by the analysis of an example. The results show that the control strategy is helpful to reduce the fatigue load intensity and reduce the operation and maintenance of the WF and the cost of power generation, which can improve the economy of the power system.

5. An analytical review on the evaluation of wind resource and wind turbine for urban application: Prospect and challenges Zinat Tasneem, ……..et al 2020

Wind energy is a promising scheme in the power generation sector due to pollution-free power production and wind resources' sufficiency worldwide. Installing wind turbines in all the possible extents can mitigate the rising energy demand. Built-up areas possess high potential for wind energy, including the rooftop of high-rise buildings, railway track, the region between or around multistoried buildings, and city roads. Harnessing wind energy from these areas is quite challenging since it has dramatic nature and turbulence for higher roughness on urban surfaces.

This review paper endeavors to highlight the present status of urban wind farm technology and its commercial and environmental aspects. Observations and upcoming research trends have been presented based on up-to-the-minute information. It is concluded that further investigation of wind mapping and the suitable design of turbines is essential to make the urban wind farm a reliable and feasible option for decentralized power generation.

6. Small Scale Wind Turbines Optimized for Low Wind Speeds T. Letcher, The Ohio State University, Columbus, OH……2020

A combination of common vertical axis wind turbines (VAWT) rotors was designed and tested for optimal performance in low wind speeds. The Savonius rotor creates high torque and is self starting even at low wind speeds, but is relatively low in efficiency rating. The Savonius rotor is used to start the straight bladed Darrieus rotor. The Darrieus rotor is not a self starting rotor, but has much higher efficiency than the Savonius rotor. The combination of rotors increases the total power of the turbine in lower wind speeds.

7. Wind turbine performance analysis for energy cost inimization Yassine Charabi & Sabah Abdul-Wahab ……..2020

The use of wind energy worldwide has overgrown in recent years to reduce greenhouse gas emissions. Wind power is free, but the installation and maintenance of wind turbines remain very costly. The size of the installation of the wind turbine is not only determined by wind statistics at a given location, but also by turbine infrastructure and maintenance costs. The payback time of the turbine is dependent on turbine energy costs.

This study estimates the wind power generation capacity of Northern and Southern Oman and discusses the selection of the most economical, efficient and reliable wind turbines in Oman. HOMER Pro Software was used in this paper to evaluate the

wind energy data in the north and south of Oman and to provide well informed guidance on the most suitable turbines for the power needs of each area. Six different standard wind turbines were measured and compared in terms of the cost of energy and performance. The simulation analysis reveals that the DW54 turbine is the best possible turbine to generate electricity in northern Oman at $0.119/kW.

Due to the difference in the wind regime between the north and the south of Oman, the simulation showed that the Hummer H25.0– 200 kW turbine is the best option for south Oman with power generation at $0.070/kW.

The northern wind turbine plant can efficiently contribute to decarburization of the energy sector in Oman, with a potential reduction of CO_2 emission approximately 19,000 tons/year in comparison to natural gas and 28,000 tons/year in comparison to diesel. In the Southern Power Plant, carbon emissions are reduced by 18,000 and 12,000 tons/year compared to diesel and natural gas.

8. Analysis of Wind Turbine Using QBlade Software To cite this article: Mustafa Alaskari et al ……2019

Owing to the fast development in the energy field, the demands are increasing to improve energy efficiency and lifetime of wind turbine. The wind blades are considered as the most important and expensive part in the wind system. Therefore, it's important to understand deeply the behaviour of turbine blades. In this research paper, full details were presented to analyze and optimize the behaviour and performance of the blade of the small horizontal axis wind turbine (less than 1 KW). QBlade software was used to simulate the wind turbine blade during the working conditions.

The mathematical formulations which used in QBlade software were based on the Blade Element Momentum method (BEM). It was studied deeply the effect of design parameters (Twist Angle and Chord length) on the behaviour and performance of the wind turbine. It was used SG6043 airfoil for 10 different sections of 1.17 m blade length. The obtained results were of high accuracy, and it was proved that the QBlade software is reliable to analyze the blades of wind turbine. The paper exhibits the necessary steps to build and optimize the blade of wind turbine, in addition to the features and advantages of the software.

9. Windmill Power Generation Using Mult-Generator and Single Rotor by S. Siva Sakthi Velan, G. Muthukumaran S. Bala subramaniyan……et al 2019

The aim of the paper was "to produce current using multi generator and single rotor". This paper proposes multi-generator to address potential challenges: dimension, cost and reliability. The two electromagnetic induction generators are desired to share the single shaft through straight bevel gears. These poles of the two generators will be changed as alternate to parallel. This paper discussed about the design procedure of gears, gear life and wind turbine rotors. The output current is stored in series of battery to appliances through converter and step up transformer. In this paper The Construction, working, parts of wind-mill, materials are discussed in detail.

10. Design and Simulation of A Small Wind Turbine Blade with Qblade and Validation with MATLAB by- Md. Robiul Islam, Labid Bin Bashar ……et al 2019

This paper presents designing blades of small horizontal axis wind turbine for low wind speed area. In this case, Blade element momentum theory has been employed to find optimum value of chord length and twist angle. The blade performance has been illustrated in terms of coefficient of power, coefficient of thrust, coefficient of torque and so on. All this design procedure and analysis have been undergone with the help of Qblade, a dedicated as well as validated software for designing and simulating of wind turbine. Moreover, it has been validated with the help of MATLAB by implementing blade element momentum method. The simulation result from Qblade shows that rotor can extract maximum 48% wind energy having start-up speed of 2 m/s

11. Analysis of Wind Turbine Using QBlade Software by Mustafa Alaskari … 2019

Owing to the fast development in the energy field, the demands are increasing to improve energy efficiency and lifetime of wind turbine. The wind blades are considered as the most important and expensive part in the wind system. Therefore, it's important to understand deeply the behavior of turbine blades. In this research paper, full details were presented to analyze and optimize the behavior

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12. Design and Analysis of Ducted Wind Turbine for House Hold Purpose Priyanka.Chore, Dr. L.G.Navale……ET AL 2018

An Energy harnessing from non-conventional energy sources has become necessary due to drawbacks of conventional sources. All these sources are renewable or inexhaustible and do not cause environmental pollution. Tremendous work done on wind energy conversion and windmill. Convention windmill has some disadvantages like large size of blades, maintenance complications and harmfulness to ecosystem. Ducted Wind Turbine means increased velocity, is the system that uses the principles of flow of fluids through convergent section, so as to increase incoming air velocity at throat section.

In Ducted Wind Turbine system, air captured from height with initial natural velocity and passes it through closed reduced area section to the ground. Air flow through convergent section of venturi, so we get higher air velocity at ground level. At throat section of venturi where the turbine is placed to get desired output. The main advantages of Ducted Wind Turbine over traditional windmill will be as; conversion of energy system will be placed at ground level, so to reduce damage and maintenance.

Comparatively lower blade size required for same energy output due to high air velocity at blade plane, less effect on ecosystem due to enclosed energy conversion system. Mainly the manufacturing and installation cost will be reduced largely.

13. Rotor Blade Performance Analysis with Blade Element Momentum Theory by Faisal Mahmuddin……2017

In order to optimally explore and utilize wind energy, an optimal design of wind turbine propeller blades needs to be obtained. Therefore, a computational method to analyze and optimize the performance of the blades needs to be developed. For that purpose, a computational method based on the Blade Element Momentum (BEM) theory is developed in the present study. In this method, the propeller blade is divided into several elements and it is assumed that there is no aerodynamic interaction amongst the elements.

Furthermore, the equations from momentum and blade element theories are combined to obtain equations which are useful in blades design process. In the analysis, tip and root losses proposed by Prandtl are also implemented. The computation results are validated using Qblade software.

A good agreement can be found from comparison of the results computed from the developed BEM and QBlade.

III. CRITICAL REVIEW OF LITERATURE

- Wind power has been a growing potential for power generation
- Roof top application of wind turbine has not been initiated yet
- Wind power can be a supplement or main power for house hold applications
- Designing a light weight wind turbine for roof top application for medium and low wind speed zones is a upcoming challenge for researchers
- Ducted wind turbine I a new solution for the medium and low wind zone.
- Modified wind profile with new material like carbon fiber can be a solution for wind turbine design

IV. ADVANTAGES

- Turbines create clean energy without producing any emissions that could cause damage to the environment.
- Capturing power from the wind is free and qualifies as a renewable resource.

- The total cost of purchasing and installing a wind turbine can usually be recouped over a period of several years.
- If you create more power than you use, you can sell the excess to your local energy company.
- You may qualify for tax incentives at the local or national level

V. DISADVANTAGES

- There are a lot of initial costs associated with installing a wind turbine.
- Turbines require a lot of land.
- Turbines require wind to generate power. If you live in an area that doesn't get enough wind, it may not be a good choice for your situation.
- Some areas have restrictions in place regarding the use of turbines in residential neighborhoods. Check with your local building department.
- Your neighbors may not like the way that your turbine looks and may be offended by the noise that it makes.
- In terms of efficiency, turbines usually operate at approximately 30% capacity. Although this seems low, it is still higher than solar panels, which typically operate at just 15% capacity.
- Turbine blades can sometimes injure or kill birds.
- Lightning can cause damage to wind turbines.

VI. CONCLUSION

At first glance, it might seem like the disadvantages outweigh the advantages. When you consider that wind energy is far more environmentally-friendly than traditional energy sources, however, it is easy to see that it is worthwhile. As long as you can As long as you can afford to install a wind turbine and you live in an area that gets enough wind, the power generated by the turbine can save you a lot of money while at the same time reducing your carbon footprint.

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[4] Masdari , Esmail Mahmoodi ……ET AL 2021

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