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An Investigation on Performance Assessment of Renewable Energy Systems

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Abstract: The field of green energy is an emerging area in electrical engineering domain.It is high time to analyse what are the vital issues involved in this area for apt implementation of a specific renewable source for the production of energy.A trade off should be identified between the extreme profitability and the threats in its implementation.This paper explores to the information on what are the global scenario on solar and wind energy systems.As of now the installed capacity of power in terms of renewable energy is only around 35GW.This needs to be increased to around 175GW by the year 2022.This paperexplores about the major initiatives which are taken place to achieve this target.The design of various accessories involved in renewable energy production plays a major role in the productivity of energy.The paper throws light on to the design aspect of wind mill systems for meliorateunderstanding

Index Terms: Renewable energy, solar systems, wind energy, wind mill, turbine design.

I. INTRODUCTION

The renwable energy generation has become the need of generation as there exist a scenario of depleting conventional energy resources. Renewable energy the so called green energy has been implemented in many places like roof tops, Airports and empty fields. Green Energy saves us from increased pollution which is the curse of present generation. It is the requirement of the public that there should be enough comfort to use the electrical equipments without actually polluting the environment. The conventional energy resources like coal and nuclear power plants emit various oxides of carbon, nitrogen, sulphur as the by-product of coal and atomic processing. Oxides of sulphur leads to acid rain while in crease in carbon monoxide and carbon dioxide leads to increased global warming. These oxides are addressed as the green house gases.

India as developing and populated country is now facing a scenario to implement maximum possible renewable energy systems to keep the environment clean and to meet the demand.to take this discussion further it is important to know what is the current scenario of renewable sources in India and how well it is integrated to the existing grid system. India at present stands at the 11th largest economy and 4th largest in the purchase of power. Out of the major renewable sources, India stands at one among the top countries in the case of solar energy potential and obviously the wind energy, hydro power, biomass energy etc are also put in one of the top position.

As per the current scenario the installed capacity of power in terms of renewable energy is only around 35GW [1]. The aim of the power sector is to increase this power capacity to around 175GW by 2022.Energy from hydro potential is a major source in the highest rainfall places like Arunachal Pradesh, Assam, Nagaland, Manipur, Mizoram etc. In India around 4096 sites are identified to be apt for the implementation of Hydroelectric power plants. These projects are capable of producing around 25MW power. Even if this is considered as small proportion of energy, this could be sufficient for a small scale rural electrification. Renovation and Modernization plays an important role in generating electricity in a more effective way[2].

There are other countries like China, Canada, USA etc are producing hydro electric power in large scale which contributes to the cumulative power generation globally[3].The research is still going on how to improve the efficiency of hydro electric power stations as this is one of the major sector of power generation. Optimized techniques are implemented to design hydro turbines for maximum efficiency[4].The generation op power using water resources by various countries are better demonstrated byfig.1

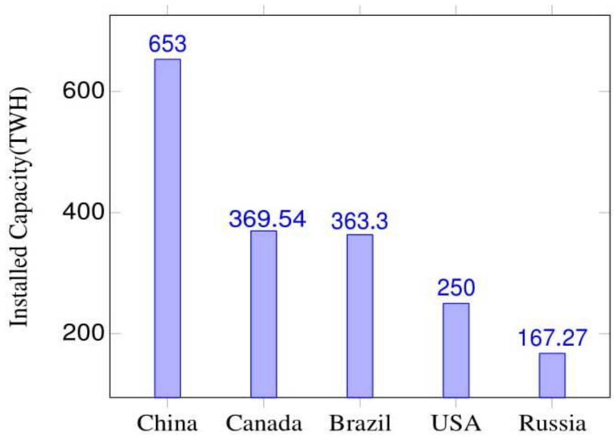

Fig.1:CountrieswhichproducelargestHydroPower

II. SOLAR ENERGY SYSTEMS

In terms of solar energy ,there exists international solar alliance between 121 countries across the world

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and is iden- tified that there is a temperature range of 25°C to 27.5°C between the tropic of Cancer and Equator,which points to a large potential of solar energy[5]. The details are shown in fig.2.

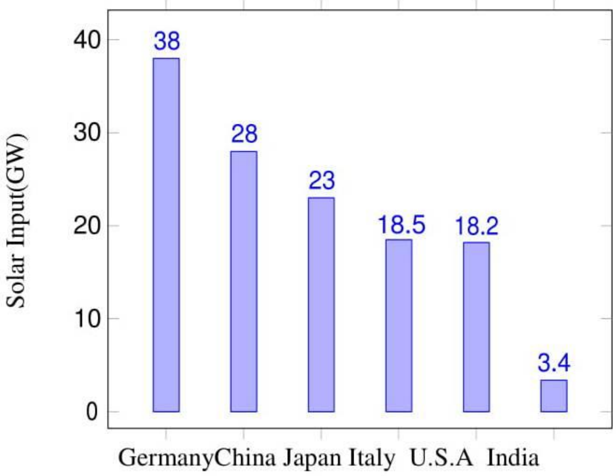

Fig.2:CountrieswhichproducelargestSolarPower

The implementation of photovoltaic cell in the solar panel has given a new direction to solar power harvesting.They have the advantage of low energy factor and less maintenance as they have no moving parts [6].Mirrors and parabolic dishesare more helpful in concentrating the solar power to a point and to produce sufficient heating[7].As of now India's solar power installed capacity has reached 23GW.The state contribute to highestsolarpowerinIndiawhichisshowninthetable1I.

Jawaharlal Nehru national solar mission has aimed at 20 million square meters solar thermal collectors across the country by by 2022.Solar energy can be used in many areas like solar water heaters and other domestic uses. But with a large installed capacity we can synchronize the energy with the grid system.

Thirteen states in India has come up with solar policy sup- porting grid connected roof top systems like Andhra Pradesh, Gujrath, Haryana to name a few [8] .In April 2014, Reserve Bank of India has included projects on renewable energy under priority sector lending with a limit of about fifteen crores Indian ruppees for solar roof top and for ground mounted systems. seventeen solar parks are already approved with an installed capacity of 12,759MW.

III. WIND ENERGY SYSTEM

Wind power generation in India has significantly improved in recent years. The total wind power capacity is seemed to be 34.293 GW by 2018.It is mainly spread across the north west and southern regions. Wind velocity surveys have to be carried out to find the potential in wind energy generation. The regions of Saurashtra and Coimbatore in Tamil Nadu had been identified as promising areas for windmill installations. Wind Power Potential is also identified in Andhra Pradesh, Gujrat, Karnataka etc. Wind power capacity of India by March 2018 is 34,046MW,making India the fourth largest wind power generation country in the world[9].

A. Wind TurbineDesign

The main aspect of wind turbine design is aero-dynamical performance. We need to also consider the mechanical strength criteria with various economical aspects. Other critical parameters are number of blades ,blade shape, blade length, tower height etc [10]. when the number of blades are in- creased the aero dynamic efficiency increases. When we move from 2 blades to 3 blades the efficiency increases about 3%.But as we increase the blades ,cost of the system also increases. Blades need to be thinner for aerodynamically efficient operation. Therefore for mechanical strength, thick root to with stand axial windloa disprovided[11].

A moving machine generally experiences fluid flow at different velocity than the original velocity. This velocity can be named as relative velocity. The relative velocity can be expressed as equation 1

$$\dot{V}_{relative}=\dot{V}_{Actual}-\dot{V}_{blade} \quad (1)$$

The relative speed is felt at a particular cross-section of the blade.Thelift force experienced by the wind turbine blade is perpendicular to the relative or apparent velocity.The lift force increases in proportion to the angle of attack along with this a desirable amount of drag force also increases.This force effectively opposes the lift force and therefore a wind blade can give highest performance when lift/drag ratio is maximum.Thegraphicalrepresentationisshowninfig.3

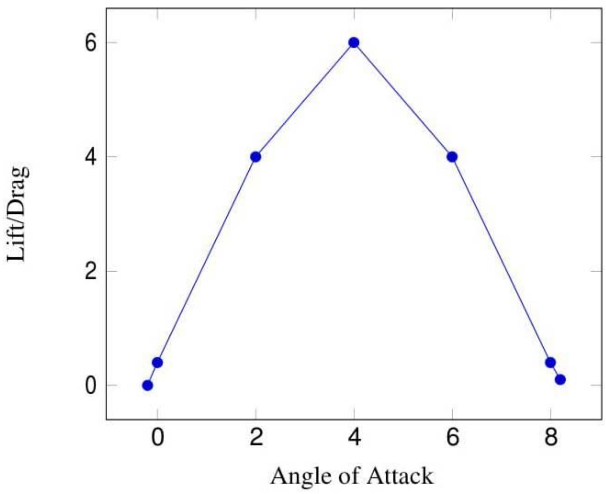

Fig. 3: Wind Blade Design

The angle corresponding to maximum lift to drag force is addressed as optimum angle of attack[12]. The flow velocity is usually uniform along the length of blade. But the blade velocity shows an increased value when it is moved to the tip. Because of this the apparent velocity of the blade also differs and therefore a continuous thrust is advised towards the tip of the blade to keep angle of attack to the optimum value.

As the wind conditions are not constant, the pitch control of blades is also equally relevant[13]. This is done by making the blades to rotate in its own axis in-order to achieve optimum angle of attack.There are many algorithms developed to find out the pitch of blade, by taking the inputs as wind condition and turbine characteristics [14].

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TABLE I: Solar Power Generation in India

Sl.No.	State	% Generation	Installed Capacity(GW)
1	Karnataka	24	5.1
2	Telangana	16	3.3
3	Rajasthan	11	2.3
4	Andhra Pradesh	11	2.3
5	Tamil Nadu	9	1.8
6	Gujarat	7	1.4
7	Madhya Pradesh	6	1.3
8	Maharashtra	5	1.1
9	Punjab	4	810
10	Uttar Pradesh	3	635
11	OtherStates	4	

The blade length also plays a major role in the wind power extraction. The power extracted from the wind is given by the equation

$$P=(1/2)\eta\rho A(V_i)^3 \quad (2)$$

$$P\alpha L^2 \quad (3)$$

Here the challenge is that with increase in blade length, the axial velocity of blade increases and hence the blade tip may get deflected so that there occur collision of blades. For increased blade length heavy mechanical structures are required which leads to heavy investments. There can be a problem of highest noise also. Another parameter in turbine design is determination of tower height. The power production is directly proportional to the wind velocity therefore the velocity of wind is a matter of concern.[15]

$$P\alpha V^3 \quad 1 \quad (4) \quad 1 \quad 1 \quad 1$$

Thewindspeedvarieswiththealtitudeisasshowninfig.4Asth evelocityincreaseswith altitude , the height of the tower can be selected as maximum as possible. Difficulty in transportation seems to be a problem into werheight design. Among the above discussed design aspect of wind turbine, the pitch control is apart where at most concentration is required.

In small wind turbines the pitch control is not included as there is a trade off between the installed cost and the power produced. Most of the pitch control systems are found in medium and large wind turbines. Pitch control is a control done in the longer axis of blade in order to include the optimum angle of attack of the wind. There is a motor installed in the rotor part of turbine and the motor is connected to a small gear which in turn is connected to a larger gear to obtain the exact pitch control. This control is called as electric pitch control system. There is also a control system called as hydrolic pitch control. The idea is best demonstrated by fig.5

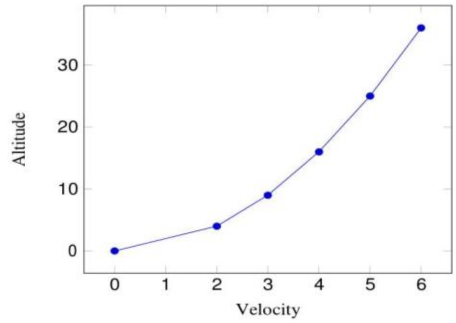

Fig. 4: Variation of wind speed according to altitude

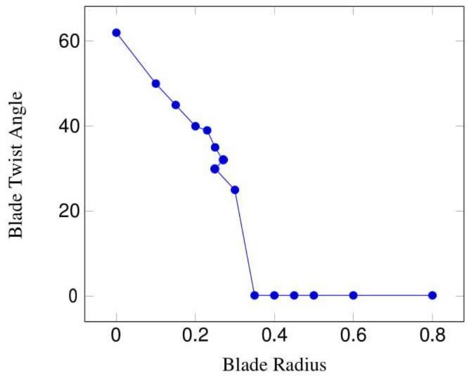

Fig. 5: Variation of Blade Twist Angle

Wind turbine can be of horizontal or vertical but both work with the principle of thrust. Energy contained in the wind is given by the equation

$$E=(1/2)mV_1^2 \quad (5)$$

V_1=Undisturbed wind speed at infinite distance

$$Power= (1/2)mV^2 = 1/2(\rho AV)V^2 =1/2\rho AV^3 \quad (6)$$

here ρ is the density of air and A is the area through which the wind passes.

With reference to the above equation it can be inferred that a slight change in wind speed will affect the power developed. Here ρ is a variable quantity but usually for analysis ρ is taken as $1.2kg/m^3$. The fig.6 shows a wind turbine where the cross sectional area is denoted by $A_0$and the wind velocity entering the drum is V_α

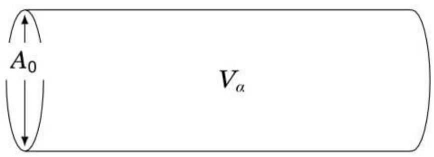

Fig. 6: Wind Turbine Cylinder

Let $V_1$and P_1be the wind velocity and pressure which enters at the left side of the wind turbine, then the velocity and pressure will undergo a change as it proceeds through the turbine. The pressure changes to P_1^1before the point of power extraction. Let the wind pressure which comes out of the point of extraction be $P_2$and the corresponding velocity is V_2. Let the end velocity and the end pressure of the turbine be $P_1$and V_3respectively. The in pressure and the out pressure remains same if the power extraction is ideal. This is shown in fig.7

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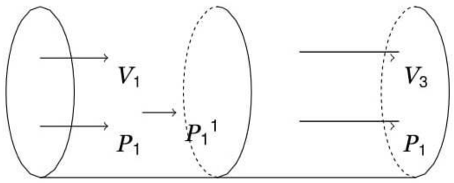

Fig. 7: Wind Turbine Cylinder with pressure and Velocity parameters

B. Design calculation

From the above section the analysis can be done based on Bernauli's principle. From figure.7. the following equations could be written.

$$1/2\rho V_1^2+P_1=1/2\rho V_2^2+P_1^1 \quad (7)$$

$$1/2\rho V_3^2+P_1 \;=1/2\rho V_1^2+P_2 \quad (8)$$

$$P_1^1-P_2=1/2\rho(V_1^2-V_3^2) \quad (9)$$

$$Thrust=A(P_1^1-P_2) \quad (10)$$

$$=1/2\rho A(V_1^2-V_3^2) \quad (11)$$

Thrust can also be calculated as rate of change of momentum.

$$T=m(V_1-V_3)=\rho AV_2(V_1-V_3) \quad (12)$$

When equation 11 & 12 is equated, it is found that

$$1/2\rho A(V_1^2-V_3^2)=\rho AV_2(V_1-V_3) \quad (13)$$

$$V_1 + V_3=V_2 \quad (14)$$

$$V_2=1/2(V_1+V_3) \quad (15)$$

An axial interference factor (a) decides the power extracted by a wind turbine.

$$V_2 = V_1(1-a) \quad (16)$$

$$V_1(1-a)=1/2(V_1+V_3) \quad (17)$$

$$V_3 = V_1(1-2a) \quad (18)$$

Power extraced is

$$1/2\rho AV_2(V_1^2-V_3^2) \quad (19)$$

$$P=1/2\rho A(V_1)(1-a)(V_1^2-(V_1(1-2a)^2) \quad (20)$$

$$P = 1/2\rho AV_1^3[4a -8a^2 +4a^3] \quad (21)$$

$dp/da= 0$ for maximum power extracted;

$$dp/da=3a^2-4a+1=0 \quad (22)$$

$$a =1,1/3 \quad (23)$$

The axial interference factor gives the idea that if a=1 , it offers complete blocking and if a=0, it offers complete permission for wind to pass through. Therefore if we substitute a=1/3 in the equation of power extracted then

$$P=1/2\rho AV_1^3(16/27) \quad (24)$$

The first term which is $1/2\rho AV_1^3$is the power contained in the wind.

C. Wind Turbine based on the principle ofthrust

The conventional equation for Thrust is

$$Thrust=C_f\rho AV_1^2 \quad (25)$$

here $C_f$is the forcecoefficient.

If the disc moves with a velocity of U_1, then the force experienced by the disc will be

$$C_f\rho A(V_1-U_1)^2 \quad (26)$$

Therefore the power extracted from the wind power is $C_f\rho A(V_1 -U_1)^2U_1$

Here we have two extreme cases, if the disc does not move then $U_1$is zero and hence power is zero. If the disc moves withavelocityV_1thenagainpowergoestozeroasV_1=U_1. Therefore here also there is a possibility of maximum power between these two extremities.

$$dp/du_1= C_f\rho A(V_1^2- 4V_1U_1 +3U_1^2 \quad (27)$$

Lets say

$$\gamma=U_1/V_1 \quad (28)$$

if we solve this we get the solution as $\gamma=1 or 1/3$

$$Power=(1/2)C_f \;\rho AV_1^3(8/27) \quad (29)$$

Ideally the value of $C_f$can be assumed as 1. Here the ideal efficiency is reduced by 50% as this demonstrates a thrust based wind turbine. this in-turn gives the idea that if it is necessary to get high efficiency out of wind turbine it should not be operated in thrust basis.

All the modern wind turbines operates on the basis of aerodynamic principles and not based on the principle ofthrust duetothisreductionin efficiency.

1) The Aerodynamic Principle of Wind Turbine: The air foil here is resembled to the wing of a bird where the shape of wing decided the flow of air. The curved shape of the wing forces the air to flow in a curved shape manner above the wing as shown in fig.8

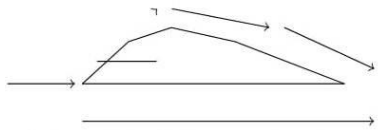

Fig. 8: Wind flow in air foil

As seen in the diagram the wind above the air foil has to travel through a long route and below has to flow through a shortest route and hence based on Bernauli's principle, there occurs an upward lift to the air foil. In this principle there occurs two types of forces which are drag force and the lift force. In practical case the wind velocity can be in any direction to the air foil say at some particular angle. In such case, the speed seen by the air-foil has to be considered. the movement of the foil will be in the resultant direction of speed seen by the foil. This is essentially called the relative wind speed.

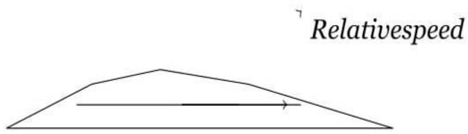

Fig. 9: Relative Wind Speed

the drag force and the lift force will be now in terms of the relative direction of wind. The drag force will be in the direction of relative velocity and the drift force will be orthogonal to it. In a properly designed wind blade the lift force has to be larger than drag force.

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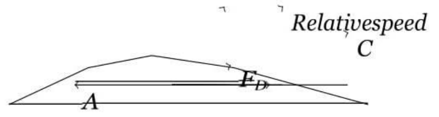

Fig. 10: the Lift and Drag Force

The force F_T has a horizontal component in the direction of motion of the air-foil and the air-foil moves due to this force in all modern wind turbines. Therefore for the design of an efficient modern wind turbine, the principle of aero dynamics is utilized to its best. The design of wind blade to move in the direction of air foil is essential. If we consider two blade wind turbine, the tip of air-foil should be in the direction of blade movement.

IV. CONCLUSION

In general it is necessary to minimize the drag force and maximize the lift force in a wind turbine as drag force is acting in opposite direction to the lift. careful design of wind turbine is required in the forth coming days for effectively using the wind resources. The paper explores the sensitivity in the design of wind blades and the minimization of drag force by optimization techniques is an active area of research. The drag force is proportional to the area it faces and hence it should be made sure that it sees the least area. when the air-foil is oriented in the direction of relative wind , the drag force sees the least area. Keeping this into account all the recent wind blades are designed in a little curved manner for obtaining optimum angle of attack.

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

REFERENCES

1. Rizwan, M., Majid Jamil, and D. P. Kothari. ”Generalized neural network approach for global solar energy estima- tion in India.”IEEE Transactions on Sustainable Energy 3.3 (2012):576-584.
2. Borkowski, Dariusz. ”Maximum efficiency point tracking (MEPT) for variable speed small hydropower plant with neural network based estimation of turbine discharge.” IEEE Transactions on Energy Conversion 32.3 (2017): 1090-1098.
3. Jimenez-Estevez, Guillermo, et al. ”Heat and dust: The solar energy challenge in Chile.”IEEE Power and Energy Magazine 13.2 (2015):71-77.
4. Moreno, Emilio Garcia, et al. ”Augmentation Channel Design for a Marine Current Turbine in a Floating Cogenerator.” IEEE Latin America Transactions 15.6 (2017):1068-1076.
5. Singh, Maninder, et al. ”Efficient autonomous solar energy harvesting system utilizing dynamic offset feed mirrored parabolic dish integrated solar panel.”Wire- less Communications, Signal Processing and Networking (WiSPNET), International Conference on. IEEE,2016.
6. Hu, Eric, et al. ”Solar thermal aided power generation.” Applied Energy 87.9 (2010):2881-2885.
7. Fermia, N., et al. ”Predictive & adaptive MPPT perturb and observe method.” IEEE Transactions on Aerospace and Electronic Systems 43.3(2007).
8. Kobayashi, Kimiyoshi, Hirofumi Matsuo, and Yutaka Sekine. ”An excellent operating point tracker of the solar-cell power supply system.” IEEE Transactions on Industrial Electronics 53.2 (2006):495-499.
9. Pyrolysis Electricity Generation and Biomass *V. Nandagopal, V. Maheswari, and J. Anbarasi* J. Comput. Theor. Nanosci. 16, 428–429 (2019)

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