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RESEARCH ARTICLE

HYBRID POWER GENERATION SYSTEM USING VERTICAL AXIS WIND TURBINE AND SOLAR PANEL.

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Abstract

Among the race in the countries of the world, Energy consumption & power requirement is one of the most vital thing in the world. Due to increase in the power consumption, conventional energy resources depleting day by day. Owing to considering this and also issue of the global warming and pollution, importance of the non-conventional energy resources is increasing. Also there is a need of clean & continuous supply of power. Hybrid energy system using wind turbine and solar energy gives uninterrupted power. The electrical power from such a system can be used for various purpose. This paper deals with generation of electricity using vertical axis wind turbine (VAWT) and solar panel at affordable cost without disturbing the balance in the nature.

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Introduction:-

Now in today's world scenario competition between the various countries is growing enormously. This leads to increase in the consumption of fossil fuels at very fast rate. One day this non-renewable energy resources will deplete and also increases the pollution problem. Electricity is most often needed in our day to day life. So far the electricity is generated using the steam energy. The steam is generated using the various fossil fuels such as coal, diesel, natural gas and also using the nuclear energy. But due to the various problems such as handling of hazardous nuclear waste, ash handling is increases and also it is very costly. So considering all this, we have to find another energy resources which give us the continuous and pollution free supply of energy. There are many non-renewable energy resources like wind, solar, geothermal, tidal etc. are available. Among this for the extraction of geothermal energy needs proper site and costly equipment, so alternative to this resources, solar and wind energy resources are good one. The solar energy intercepted by earth is about 1.85×10^{11} MW. Solar panel installed are quite ineffective in cloudy and rainy season, so integration of wind and solar energy gives continuous supply of energy throughout the season. At the end of the 2013 about 640 terawatt hours energy could have potentially saved by the installed all the turbine around the globe. So such a hybrid system can give us continuous supply of energy in good weather condition and in efficient way.

Hybrid Power Generation System:-

Hybrid power generation system is the combination of the two energy resources which produces power. It overcome the limitation of individual system and produces power continuously. In this proposed system solar and wind energy are combined to take advantage of their seasonal dependency. Such a system could give reliable, pollution free

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power supply at low cost. This system does not need special location for its installation, as this energy resources are available abundantly all over the world.

Solar Energy:-
The energy produced in the sun is due to nuclear fusion. During this fusion large quantum of energy is releases and reach the earth's surface in the form of electromagnetic radiation. Solar energy available on the earth is in abundant manner and throughout the year. Solar energy is freely available. This energy is available at low cost and without pollution. Solar system has high efficiency and very low maintenance cost makes it suitable for the hybrid system for power generation. It only has problem in cloudy condition or in rainy season.

Wind Energy:-
Wind energy is indirect form of solar energy since wind is introduced chiefly by the uneven heating of the earth's crust by the sun. In contrast to direct solar radiations wind energy can be available continuously at selected sites. However the power generation is mostly depend upon the wind speed available. Advantages of wind energy is that it is clean and non-polluting. The only disadvantage is that it needs specific locations and it causes sound pollution. Horizontal axis wind turbine (HAWT) and vertical axis wind turbine are two types of wind turbine available for converting wind energy into electrical energy.

The only limitation of using individual system is that, it does not give power in all-weather condition, since many times wind is not available and same is for solar energy. By taking into account all this matter in our proposed system we use both solar energy and wind energy especially vertical axis wind turbine. Such a hybrid system can be used as standalone or in grid system. Though the capital cost is high for such a system, but standalone system can be produced at low cost. The main advantage of such system is its high efficiency and continuous power supply.

Components of Hybrid Energy System:-
Following are the essential components that are used in the Hybrid Energy System. This components are as follows.
1. Solar panel
2. Wind turbine
3. Charge controller
4. Battery
5. Inverter
6. Electrical load

Such a hybrid system is designed depend upon the considering the load and cost of the system. Design consideration includes,
1. Proper site for the installation.
2. Available solar energy per day and annually.
3. Available wind speed per day in m/s.
4. Available load on the system.

Following block diagram shows hybrid power generation system using wind energy and solar panel.

Solar panel:-
Solar panel also called as solar collector is a device which converts the incident radiation on it into the electrical energy. Solar panel consist of solar cells and has same diode as PN junction made from silicon and germanium semiconductor material. When the photon is impinged on the junction producing free electrons and potential gradient is developed across the junction. There are no. of such a solar cells in the solar panel and this solar panel are available in various size and wattage.

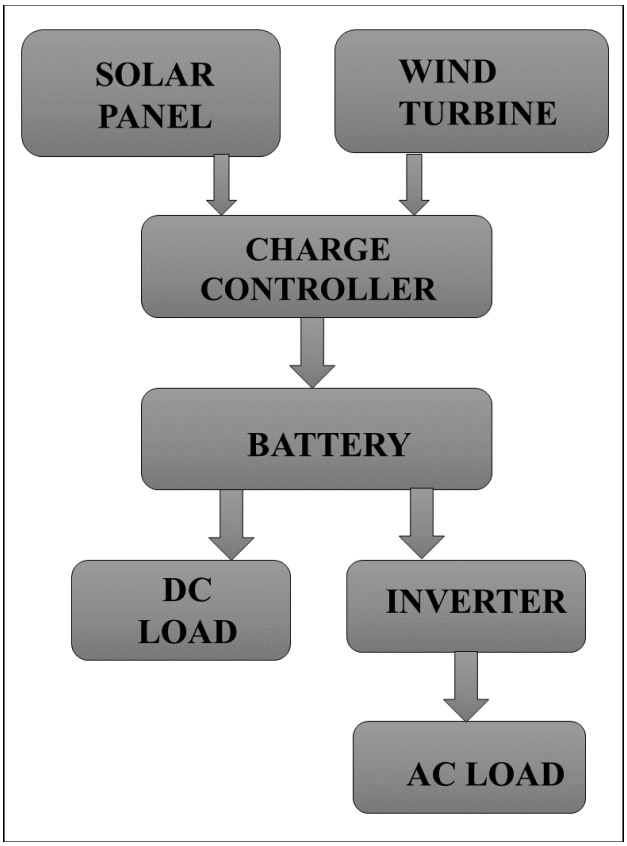

Fig. 1:- Components of Hybrid Power System.

Vertical axis wind turbine:-

There are two types of wind turbine from which power is generated, one is horizontal axis wind turbine and another is vertical axis wind turbine. In this proposed system we are using vertical axis wind turbine. Vertical axis wind turbine have various advantage over the horizontal axis wind turbine. The main advantage of VAWT is that it does not required to be pointed out in the direction of wind. Wind coming from any direction will cut the blades and power is generated. Also it has low cut in speed up to 2-3 m/s.VAWT has also the advantage is that, its gearbox and other assembly can be placed on the ground, also its maintenance is easy as compared to HAWT. Some of the other advantages are as follows,

1. It has ability to operate in wide range of wind conditions.
2. High starting torque.
3. Low noise emission.
4. It is compact in size.
5. Construction is simple and less costly.

There are various types of vertical axis wind turbine. The two main types of VAWT are Darrieus and Savonius VAWT, also multi bladed vertical axis wind turbine are available. Darrieus type rotors consists of two or three convex blades with aero foil cross section while the savonius VAWT has s-shape hence it also called as S-Rotors.

Fig. 2:- Multi bladed VAWT (Turbina)

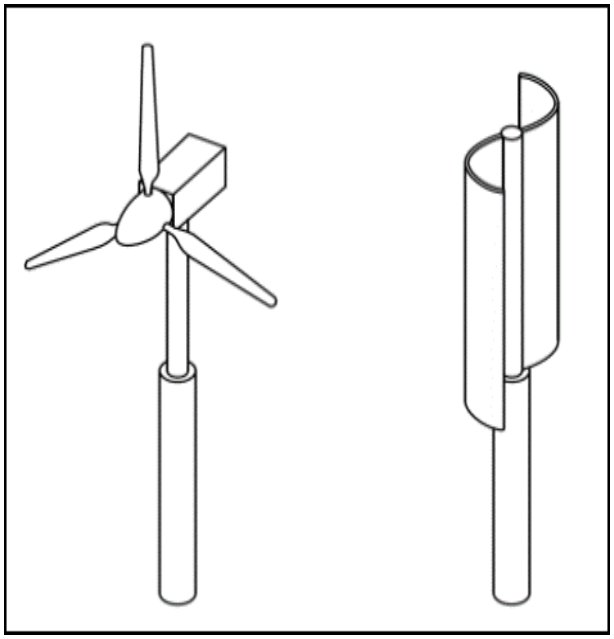

Fig. 3:- HAWT and Savonious VAWT [3**]**

Charge controller:-

The basic function of the charge controller is to control the output of both wind turbine and solar panel and to save it into battery. At various time different power is coming from both individuals, hence the required voltage is stored in battery is done by using charge controller. It simultaneously charge the battery and also gives power to the load

connected in the system. It also control the overcharging of battery along with short-circuit protection. It also control the power required for the load at different time.

Battery:-
As stated earlier, such a hybrid system can be used as standalone system or it can be used in grid system. When the system is used as a standalone system battery is necessary. Battery size is depend upon the load on the system and the output of the system. To increase the battery capacity it is suitably connected in parallel or in series connection.

Inverter and Load:-
Inverter is used to convert the DC power into AC power. Though the system uses inverter some DC load does not required it, such as street lights. So as per the application, both types of load arrangement is needed. Inverter must be high rated and quality so to avoid any breakdown in the system and as per requirement of load.

Concern Parameters:-
Wind Power:-
The total wind power is equal to the kinetic energy of wind. This kinetic energy of wind is used to rotate the shaft which further produces power. It can be given as,

$$P = \frac{1}{2} \times m \times v^2 \qquad \text{…….. (1)}$$

Where,
P is total wind power
m is mass flow rate of air (kg/s)
v is wind velocity in (m/s)
mass flow rate of air can be calculated as,

$$m = \rho \times A \times V \qquad \text{…….. (2)}$$

Where,
ρ is density of air (kg/m^3)
A is cross sectional area of wind stream (m^2)

Ideal Efficiency:-
Ideal efficiency is defined as ratio of maximum power obtained to the total power.

$$\eta = \frac{max.power}{total\ power} \text{ … … … … (3)}$$

Ideal Efficiency of wind Turbine is about 55 to 60%.

Tip speed ratio:-
It is define as ratio of the blade tip speed to the free stream wind speed.

$$\lambda = \frac{blade\ tip\ speed}{free\ stream\ wind\ speed} \text{ … … . . (4)}$$

Solar cell efficiency:-
Efficiency of the solar cell can be defined as,

$$Efficiency = \frac{max.power\ output}{incident\ intensity \times area\ of\ device} \text{ … … … … … … (5)}$$

$$Efficiency = \frac{V \times I}{Insolation \times Area} \text{ … … … … … … (6)}$$

Where,

V= Cell voltage
I= Current

Proposed Analysis of VAWT:-
Power output and efficiency from VAWT is largely depend upon the angle at which wind is hitting the wind turbine blade. So it is necessary to find out the relationship between power output and efficiency with blade angle.

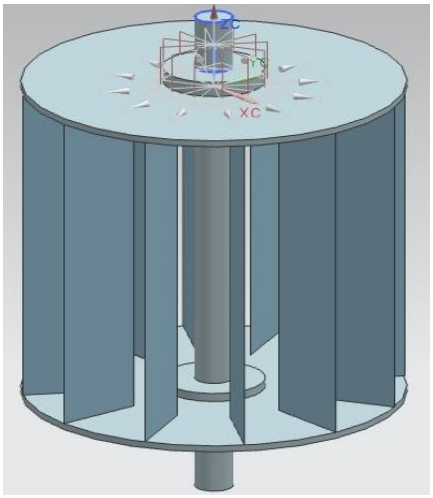

Fig 4:- 3D model of VAWT

Fig. shows the 3D model of multi bladed VAWT created using unigraphics 3D software. It is predicted that there might be relationship between maximum power output and efficiency at a particular blade angle such that,

$p \propto \theta,\ \eta \propto \theta$
$p_{max}, \eta_{max} = c \times \theta \times w_s$ ..... (7)

Where,
p = power output
η = Efficiency
w_s = Wind Speed
c = Constant
θ = Particular blade angle at which power and efficiency is maximum.

So by manufacturing such kind of VAWT and taking readings at different blade angles $(15°, 30°, 45°, 60°, 75°, 90°)$, max. Power output and efficiency at a particular blade angle can be found out. Also max. Power output and efficiency at a particular wind velocity at all blade angles can be found out. It will ultimately help in to set the blade angle in such a fashion that max. Power output and efficiency is obtained. It will also help in to find the optimum power and efficiency at a particular wind speed and at a different blade angles.

So such a hybrid system is very helpful in the areas where the wind and the solar intensity is available abundantly. Owing to considering the various advantages of VAWT over HAWT such a system can be implemented at low cost. Still the cost of the solar panel and wind turbine is very high, it can be reduce by increasing the use of non-conventional energy sources and also by widening the research in this field.

Conclusion:-

Considering the global energy crisis, use of the non-conventional energy resources has to be increased. By combining such a system, effectiveness is increase and also the seasonal dependency of the individual system can be overcome by use of hybrid energy system. Also the various advantages of the vertical axis wind turbine makes it suitable for to use in such a system. Vertical axis wind turbine can be made at very low cost by using various techniques and also by cheap material such as wood, aluminium, galvanized steel etc. Savonius VAWT can also be

fabricated by cutting hollow metallic or plastic cylinder. Such a system can be implemented in remote areas as well as in the road divider using VAWT. So this system is cost effective, efficient and non-polluting. It also has long life span with less maintenance. Overall it is a reliable solution for energy crisis across globe.

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