Study Analysis of Hybrid Power Plant (Wind-Solar) - Vertical Axis Wind Turbine-Giromill Darrieus Type with Evacuated Tube Collectors

C.Bhuvaneswari and R.Rajeswari

ABSTRACT: The vital input for the growth of any nation is energy. In India, so many types of energies playing a major role. It has become inevitable to seek nonpolluting renewable energy sources for the power generation. So Renewable energy technologies range from the well established, such as hydro power to the emergent. Each technology has its own individual measurement and requirements. A steps involved in hybrid system deserve extra attention because of its importance or uniqueness. Hybrid system is most often used for larger applications such as village power, residential systems where generators already exist and in applications like telecommunications where availability requirements are near 100 percent. Among this wind energy and solar energy plays a vital role in many countries. The growth of installations of Wind turbine and solar plate collector is increasing every year. In wind power plant, Giromill Darrieus type vertical axis wind turbine provides high good efficiency, small torque ripple and low stress on the tower which contributes to good reliability, self starting. In solar power plant , Evacuated tube solar collectors are well suited to commercial and industrial heating applications and can be effective alternative to flat plate collectors for domestic space heating in areas, especially where it is often cloudy and it is also more efficient. This paper presents the study analysis of wind –solar hybrid power plant by using vertical axis wind turbine-GiromillDarrieus type with evacuated tube solar collectors.

Key words: **Wind Turbine, Giromill Darrieus type, Solar collectors, Evacuated tube collectors.**

I. INTRODUCTION:

The oil crises in the early 70's and the steadily increasing environmental concern have initiated a major interest for the exploitation of renewable sources of energy for the generation of electric power. Most promising among them appear be the wind and at a second level, the solar energy.

Peoples are looking for ways that will enable them to curb and reduce the greenhouse gas emissions so that the planet can be saved from the harsh effects of global warming. The wind turbines have proven to be most effective way of dealing with these emissions. The first one to be designed was the horizontal axis wind turbine. Now there is some new and modern vertical axis wind turbine designed. The main advantage of a vertical wind axis turbine over a horizontal axis wind turbine is its insensitivity to wind direction and can be located near the ground. Among then vertical axis wind turbine Giromill Darrieus type is the advantage because it provides high good efficiency, small torque ripple and low stress on the tower which contributes to good reliability, self starting. Similarly in solar power plant the Heart of a solar thermal system is a solar collector. It absorbs solar radiation as heat and transfers useful heat to the solar system. There are different design concepts for collectors such as flat plate collectors, evacuated flat plate collector, evacuated tube collector and concentrating collectors.

Among this evacuated tube collector are the more efficient and can achieve very high temperature. In this paper the study of wind solar hybrid power plant with Giromill Darrieus type vertical axis wind turbine and evacuated tube collector has been presented.

II. WIND POWER GENERATION SYSTEM

Differential heating of the earth surface by the sun causes the movement of large air masses on the surface of the earth, ie, the wind. Wind power generation has been recognized has an environmentally friendly and economically competitive means of electric power generation.

In meteorology, winds are often referred to according to their strength and the direction from which the wind is blowing. Short bursts of high speed wind are termed as gusts. Strong winds of intermediate duration are termed squalls, long duration winds have various names associated with their average strength, such as breeze, gale, storm, hurricane and typhoon. Wind occurs on a range of scales from thunderstorm flows lasting lens of minutes, to local breezes generated by heating of land surfaces and lasting a few hours, to global winds resulting from the difference in adsorption of solar energy between the climate zones on earth. The two main causes of large scale atmosphere circulation are the differential heating between the equator and the poles, and the rotation of the planet.

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Wind power can be computed by using the concept of kinetics. The wind mill works on the principle of converting kinetic energy of the wind to mechanical energy.

Power density in moving air is given by

$$P_w = KU_w^3 \ w/m^2 \quad (1)$$

Where U_w = Wind speed in km/hr and

$$K = 1.3687 * 10^{-2} \quad (2)$$

Theoretically a fraction 16/27 = 0.5926 of the power in the wind is recoverable. This is called Gilbert's limit or Betz co-efficient. Aerodynamically efficiency for converting wind energy to mechanical energy can be reasonably assumed to be 70%. So the mechanical energy available at the rotating shaft is limited to 40% or at the most 45%of wind energy.

III. WIND TURBINES:

Wind turbines are the machines that convert the kinetic energy into mechanical energy. When the mechanical energy is converted to electricity, then the machines is referred to as a wind turbine or a wind energy converter.

When such mechanical energy is used directly by machines such as pumps, then the machine is referred to as a wind mill.

HISTORY OF WIND TURBINES:

Wind machines have been used since 200BC in Persia for grinding grain. It was introduced in 250BC in the Roman Empire. Wind mills were used in the 14th century in Holland to drain the areas of the Rhine River Delta. In the 1900's wind mills were used in Denmark for pumps and mills. Wind mills were also used in USA and USSR to produce electricity on farms.

VERTICAL AXIS WIND TURBINE:

Wind turbines are of two types: Horizontal axis wind turbines and Vertical axis wind turbines. In a horizontal axis wind turbine, the main rotor shaft and electrical generator is placed at the top of the tower and it must be pointed into the direction of the wind. In a vertical wind turbine, the rotor shaft runs vertically.

The advantages of a Vertical axis wind turbine are that the rotor shaft is placed vertically and can be located near the ground. The generator and the gear box are placed near the ground. Thus the tower need not support it. Also the turbine need not be pointed into the wind. This makes the maintenance of the wind turbine quite easy. Also the Vertical axis wind turbine is quite cost effective. These can be placed on hilltops, on ridgelines and any areas where the force of the wind is more near the ground. Since they are placed lower, they can be used where the tall devices are not allowed by the law. The main advantage of Vertical axis wind turbine, however is that it turns in any direction with the wind.

DARRIEUS TYPE WIND TURBINE:

The Darrieus wind turbine is a type of vertical axis wind turbine used to generate electricity from the energy carried in the wind. The turbine consists of a number of aero foils usually- but not always vertically mounted on a rotating shaft or framework. This design of wind turbine was patented by Georges Jean Marie Darrieus, a French aeronautical engineer in 1931.

IV. METHOD OF OPERATION OF DARRIEUS WIND TURBINE

In the original versions of the Darrieus design, the aero foils are arranged so that they are symmetrical and have zero rigging angle, that is, the angle that the aero foils are set relative to the structure on which they are mounted. This arrangement is equally effective no matter which direction the wind is blowing in contrast to the conventional type, which must be rotated to face into the wind.

When the Darrieus rotor is spinning, the aero foils are moving forward through the air in a circular path. Relative to the blade, this oncoming airflow is added vectorially to the wind, so that the resultant airflow creates a varying small positive angle of attack to the blade. This generates a net force pointing obliquely forwards along a certain, "line of action'. This force can be projected inwards past the turbine axis at a certain distance giving a positive torque to the shaft, thus helping it to rotate in the direction it is already travelling in. The aero dynamic principles which rotates rotor are equivalent to that in autogiros and normal helicopters in autorotation.

As the aero foil moves around the back of the apparatus, the angle of attack changes to the opposite sign but the generated force is still obliquely in the direction of rotation, because the wings are symmetrical and the rigging angle is zero. The rotor spins at a rate unrelated to the wind speed and usually many times faster. The energy arising from the torque and speed may be extracted and converted into useful power by using an electrical generator.

GIROMILL TYPE:

Darrieus 1927 patent also covered practically any possible arrangement using vertical airfoils. One of the most common type is the giromill or H-bar design, in which the long 'egg beater' blades if the common Darrieus design are replaced with straight vertical blade sections attached to the central tower with horizontal supports. In low winds, the blades are pitched flat against the wind generating drag forces and starting the turbine turning cheaper and easier to build than a standard Darrieus turbine.

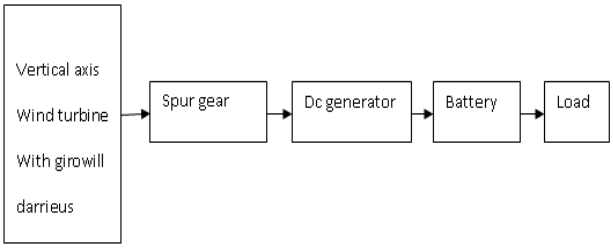

Figure.1-Wind power generation system.

V. SOLAR POWER GENERATION:

The most popular non conventional power resources are solar energy or solar heat to electricity. The sun is a continuous fusion reactor in which hydrogen combine to form helium and evolving huge amount of heat energy as per the following reaction.

$$4_1H^1 \longrightarrow {}_2He^4 + 26.7MeV \quad (3)$$

This heat energy from the sun is emitted in the universe and the earth by transmission of tiny bundles of energy particles called photons which move with finite speed (almost speed of light) and energy. When photons strike an atom, they interact with the electrons by transferring their energy and hence they are absorbed. The sun rays are composing if different wavelength spectrum from the low to the very high ranges, but UV (ultra violet) radiation, other low and very high range wavelength radiations are absorbed by ozone, oxygen, nitrogen, watervapour etc…lying above the earth's atmosphere. Thus the sun ray consists of wavelength radiations between 0.29μm to 2.3 μm (approximately).

The conversion of sunlight into electricity is done, either directly using photovoltaic (PV) or indirectly using concentrated solar power. Concentrated solar power system uses lens or mirrors and tracking system to focus a large area of sunlight into a small beam. Photovoltaic convert light into electric current using the photoelectric effect.

Concentrating solar power (CSP) uses lens or mirror or tracking system to focus a large area of sunlight into a small beam. The concentrated heat is then used as a source for a conventional power plant. Various techniques are used to track the sun and focus light. In all of these systems a working fluid is heated by the concentrated sunlight and is then used for power generation of energy.

SOLAR COLLECTORS:

The solar collectors concentrate sunlight to heat a heat transfer fluid to a high temperature. The hot heat transfer fluid is then used to generate system that drives the power conversion subsystem, producing electricity. The solar collector is the key element in a solar energy system. It is also the novel technology area that requires new understanding in order to make captured solar energy a viable energy source for the future. The function of solar collector is simple; it intercepts incoming isolation and changes into a usable form of energy that can be applied to meet a specific demand.

FLAT PLATE COLLECTORS:

Flat plate collector, developed by Hottel and Whillier in the 1950's is the most common type. They consists of i) a dark flat plate absorber of solar energy ii) a transparent cover that allows solar energy to pass through but reduces heat losses iii) a heat transport fluid to remove heat from the absorber and iv) a heat insulating backing.

EVACUATED TUBE SOLAR COLLECTOR:

Evacuated tube solar collector is very efficient and can achieve very high temperature. Evacuated tube solar collectors are well suited to commercial and industrial heating applications and can be an effective alternative to flat plate collectors for domestic space heating, especially in areas where it is cloudy.

A evacuated tube collectors contains several rows of glass tubes connected to a header pipe. Each of the air removed from it to eliminate heat loss through convection and radiation. Inside the glass tube, a flat or curved aluminium or copper fin is attached to a metal pipe. The fin is covered with a selective coating that transfers heat to the fluid that is circulating through the pipe.

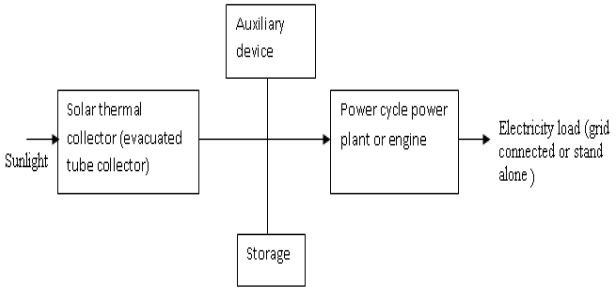

Figure.2-Solar power generation.

VI. COMBINED WIND AND SOLAR POWER PLANT :(GIROMILL DARRIEUS TYPE VERTICAL AXIS WIND TURBINE AND EVACUATED TUBE SOLAR COLLECTOR):

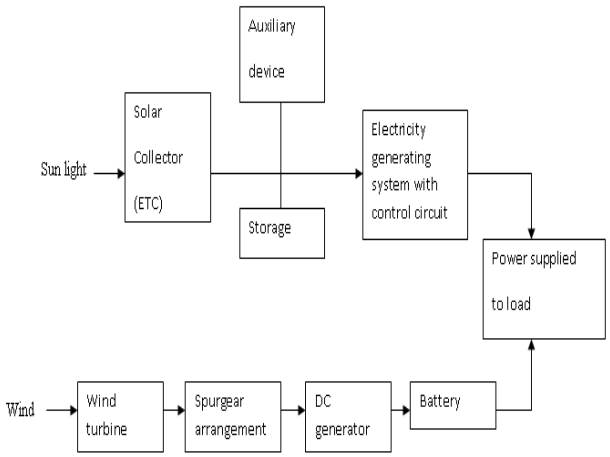

Figure.3-Combined power generation (wind and solar).

Evacuated tube solar collector can maintain their efficient over a wide range of ambient temperature and heating requirements. Evacuated tube collector works as a thermal one way valve due to their heat pipe. This also gives them an inherent maximum operating temperature which may be considered as a safety feature. They have less aerodynamic drag, which allow them to be laid onto the roof without being tied down. They can collect thermal radiation from the bottom in addition to the top. Tubes can be replaced individually without shutting down the entire system. There is no condensation or corrosion within the tubes. It captures sunlight better as they have a greater surface area exposed to the sun at any time. It is more efficient in transferring heat up to 163%.

By using Giromill darrieus type vertical axis wind turbine, in low winds the blades are pitched flat against the

wind generating drag forces and starting the turbine turning cheaper and easier to build than a standard Darrieus turbine.

VII. CONCLUSION AND FUTURE DIRECTIONS OF WORK

The paper presented here will be highly effective in all places, especially in rural areas and where the commercial electricity has not reached or undelivered. It causes no effect on nature i.e., pollution free, at the same time it won't cause any kind of accident due to lightning and highly suitable for domestic purposes. It is also useful to urban and city areas simultaneously with the commercial power supply to minimize power supply load i.e., cut short power charge. By using this system, people can save electricity charge and very less maintenance to this equipment is required.

In future we can replace the evacuated tube collector in solar power plant by a ring array concentrator. The ring array concentrator is an ultra powerful optical lens based on an array of nested ring design completely free from the light dispersion effects of conventional refractive lenses.

VIII.ACKNOWLEDGEMENT:

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