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Solar-Wind Hybrid Generation System Using Single Axis Solar Tracker

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Abstract **- As the name suggests the aim of our paper is to enhance the generation of electricity of solar-wind hybrid generation system by using single axis solar tracker. Since the efficiency of solar energy system is less than 50%, so to increase solar energy conversion we are using single axis solar tracking system with solar panel. Since we are alternating non-conventional energy resources for conventional energy resources due to environmental reasons. Thus we have to take steps to enhance the energy conversion capacity of non-conventional energy resources so as to produce bulk electricity with less economy. That is why we are using single axis solar trackers with solar panel to increase the amount of electricity generation from solar-wind hybrid generation system to provide uninterrupted power supply for the load demand.**
Keywords: **Hybrid generation, Solar tracker, wind energy**

I. INTRODUCTION

Electricity is most needed commodity for our everyday life. Electricity is being generated either by conventional energy resources or by non-conventional energy resources. The non-conventional energy resources (renewable) are a good substitute energy bankroll for the conventional energy resources. There are numerous non-conventional energy resources like Geothermal, Tidal, Wind, Solar etc. The Tidal energy has downsides like it can only be achieved on sea shores. While geothermal energy requires very lager step to extract heat from earth. Solar and wind are easily available in all geographical conditions condition. The non-conventional energy resources like solar, wind can be good substitute source for conventional sources.

Electricity generation using non-conventional energy resources has less efficiency. Energy demand increases in world every day. So to realize this demand we need to increase the efficiency of electricity generation of non-conventional energy resources. For this we use single solar tracking system with the solar panel in solar+wind hybrid generating systems. The single axis solar tracker enables the solar panel to face toward the sun from east to west by tracking its position. This enables the solar panel to convert more solar energy into electricity than the static solar panels.

II. HYBRID SYSTEM

The amalgamation of two or more system is called Hybrid System.There are numerous measures to generate hybrid energy like wind-solar hybrid, Solar-diesel, Wind–diesel etc. Among the above mentioned hybrid energy generation methods the wind-Solar hybrid diameter is more reliable because it is available in nature in ample and it is very much environment friendly [1]. Hybrid energy generation is more important because the wind is not at hands all time and solar energy is only present for approx. 8- 10 hours in a day. So for continuity of power it is important to hybridise the solar and wind power sources with the storage batteries. The hybridization in India has a greater expectancy because large population of Indian household face the problem like power cuts [2]. In this proposed system we can use both sources combined along with single axis solar tracker. Single axis solar tracker enables the PV modules to face toward the sun all the time. As the sun moves from east to west the PV modules also rotate along with the sun. Thus harnessing more solar energy than a simple PV module fixed in a particular direction at a particular angle. This will leads to continuity of electric supply. This will make system more reliable, Maintenance cost is less, Life span of this system is more. Efficiency is more. Main advantage of this system is that it gives continuous power supply.

Site allocation for Solar-Wind hybrid system: The solar-Wind hybrid system suits remote locations, where it is not easy to provide normal supply or where it is not economical. For Sun-energy, PV panels are kept on a plain ground where solar radiation can be made available without any problem. The PV panels faces the Sun directly without any hurdle. In case of a wind-mill, the wind should be available in the proper direction. Air should flow at an appropriate speed to cause rotation of the fan blades.

III. SOLAR ENERGY SYSTEM

Solar energy is an important, clean, cheap and abundantly available renewable energy [12]. It is collected on Earth in cyclic, discontinuous and dilute form with very low power density 0 to 1 kW/m2. Solar energy is freely available. It doesn't produce any gases that mean it is pollution free. It is affordable in cost. It has low maintenance cost. Only problem with solar system it cannot produce energy in bad weather condition. But it has greater efficiency than other energy sources. It only need initial investment. It has long life span and has lower emission

Units of solar power and solar energy:

In SI units, Energy is expressed in Joule. Other units are angley and Calorie,

Where 1 angley = 1 Cal/cm2.day
1 Cal = 4.186 J

For solar energy calculations, the energy is measured as an hourly or monthly or yearly average and is expressed in terms of kJ/m2/day or kJ/m2/hour. Solar power is expressed in terms of W/m2 or kW/m2

IV. WIND ENERGY SYSTEM

The wind turbine traps the wind's kinetic energy in a rotor consisting of two or more blades mechanically coupled to an electrical generator. The turbine is sated on a tall tower to magnify the energy capture. Large numbers of wind turbines are installed at one site to construct a wind farm of the desired power generation capacity [3]. Obviously, sites with steady high wind produce more energy over the year. The wind energy needs less cost for generation of electricity. Maintenance cost is also less for wind energy system. Wind energy is present almost 24 hours of the day. It has less emission. Initial cost is also less of the system. Generation of electricity from wind depends upon the speed of wind flowing.

V. DESIGN OF HYBRID ENERGY SYSTEM

The block diagram of the hybrid power generation system using wind and solar power is shown below. This block diagram includes following blocks.

i. Solar panels
ii. Wind turbine
iii. Charge controller
iv. Battery bank
v. Inverter
vi. Ac loads
vii. Dc loads

A. Solar panel

Solar panels are devices that convert light into electricity. They are called "solar" panels because most of the time, the most powerful source of light available is the Sun, called Sol by astronomers. Some scientists call them photovoltaic which means, basically, "light-electricity". A solar panel is a collection of solar *cells*. Lots of small solar cells spread over a large area can work together to provide enough power to be useful [12]. The more light that hits a cell, the more electricity it produces.

B. Wind Turbine

Wind Turbine is a device traps the wind's kinetic energy and converts it into electrical power [6]. Wind turbines are manufactured in a wide range of vertical and horizontal axis types. The smallest turbines are used for applications such as battery charging for auxiliary power for boats or to power traffic warning signs. Larger turbines can be used for supplying for domestic power supply [17]. Arrays of large turbines, known as wind farms, are being increasingly used as intermittent renewable energy and are used by many countries as part of a scheme to reduce their reliance on fossil fuels.

C. Charge controller

Charge controller limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. It may also prevent completely a battery, or perform controlled discharges, depending on the battery technology, to protect battery life. The terms "charge controller" may refer to either a stand-alone device, or to control circuitry integrated within a battery pack, battery-powered device, or battery charger.

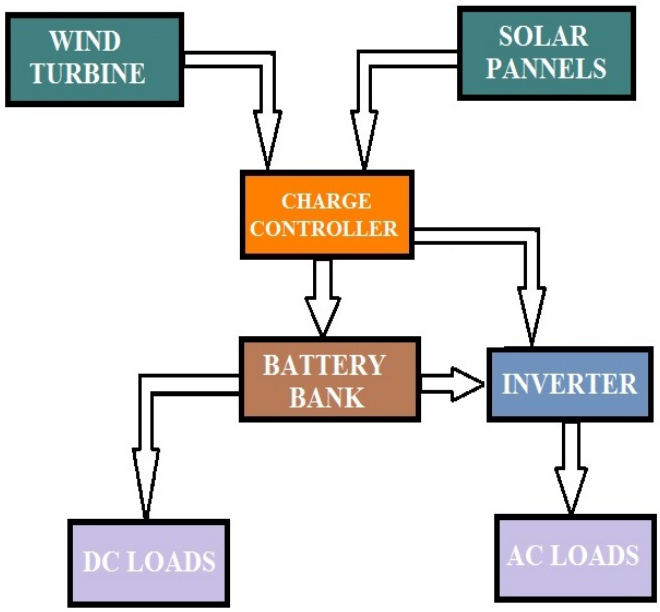

Fig. 1 Block diagram of solar+wind hybrid energy system

D. Battery Bank

The power generated from wind is not continuous its fluctuating. To provide non-fluctuating power supply we have to store the generated electricity in battery and then provide it to the load. The size of battery bank is so chosen that its meets the requirement of daily use in watt-hour and also the backup time.

E. Inverter

Inverter is need to convert DC power into AC power. As our load working on the AC supply so we need to convert DC power into AC power. We have to choose greater rating inverter than the desired rating .The pure sign wave inverter is recommended in other to prolong the lifespan of the inverter.

VI. SOLAR TRACKING SYSTEM

Trackers direct solar panels or modules toward the sun. These devices change their orientation throughout the day to

follow the sun path to maximize energy capture. In photovoltaic systems, trackers help minimize the angle of incidence between the incoming light and the panel, which increases the amount of energy the installation produces [26]. Concentrated solar photovoltaic and concentrated solar thermal have optics that directly accepts sunlight, so solar trackers must be angled correctly to collect energy.

All concentrated solar systems have trackers because the systems do not produce energy unless directed correctly toward the sun [14]. The Track Rack completes its daily cycle facing west. It remains in this position overnight until it is "awakened" by the rising sun the following morning. The attractive feature of the constructed prototype is the software solution of many challenges regarding solar tracking system. The designed prototype requires only two photo resistors to sense the light, which lessens the cost of the system. Power consumption of the system is negligible as 'wait' states are calculated perfectly with the sun's position. All these software based solution reduce the system cost far more than all other systems proposed to date.

Following data recorded shows the comparison between 12volt static solar panel and 12volt solar panel with single axis solar tracker.

TABLE I DATA RECORDED FOR A 12 VOLT SOLAR PANEL WHILE STATIC AND WITH SINGLE AXIS SOLAR TRACKER

TIME	STATIC			SINGLE AXIS TRACKER		
	Voltage (V)	Current (I)	Power (W)	Voltage (V)	Current (I)	Power (W)
7am	9	1.4	12.6	10	1.7	17
8am	9.6	1.5	14.4	10.3	1.9	19.57
9am	10.2	1.7	17.34	11.2	1.9	21.28
10am	10.7	1.9	20.33	11.6	2	23.2
11am	11.7	2	23.4	12	2.1	25.2
12pm	12.3	2.1	25.83	12.4	2.1	26.04
01pm	12.5	2.1	26.25	12.7	2.1	26.67
02pm	12.3	2.1	25.83	12.6	2.1	26.46
03pm	12.3	1.9	23.37	12.5	2	25
04pm	11.8	1.8	21.24	12.3	1.9	23.37
05pm	11.4	1.6	18.24	12	1.8	21.6
06pm	10.4	1.5	15.6	11.7	1.7	19.89

As we can see from the above data that the energy converted by the solar panel with single axis solar tracker is more than the static solar panel. The energy conversion in static solar panel is more during noon and after noon when the sun is above the head whereas energy conversion by solar panel with single axis solar tracker is more during morning and evening because the solar tracker faces the solar panel directly towards the sun which enhances the energy conversion.

The above data is shown graphically as below.

Blue graph represents the energy converted by static solar panel and red graph represents the energy conversion by solar panel with single axis solar tracker.

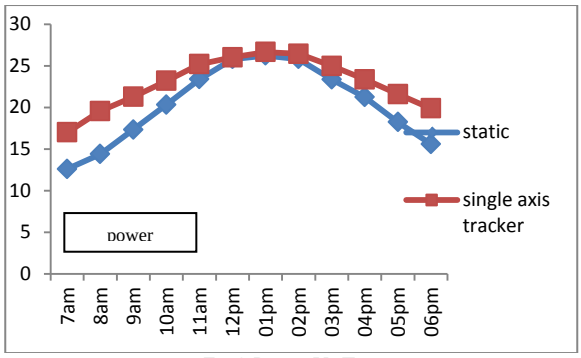

Fig.2 Power Vs Time

VII. MATHEMATICAL CALCULATIONS

The total power generated by this system may be given as the addition of the power generated by the solar PV panel and power generated by the wind turbine. Mathematically it can be represented as,

$$Pt = Pw + Ps \quad (1)$$

Where,

Pt : is the total power generated in watts
Pw: is the power generated by wind turbines
Ps : is the power generated by solar panels

A. Calculations for wind energy

The power generated by wind energy as in [20] is given by,

$$Pw = \frac{1}{2} \times C_e \times \rho \times A \times V^3 \quad (2)$$

Where,

Pw: power extracted from wind turbine with changes in wind speed,
C_e: is the fraction of upstream wind power, which is captured by the rotor blades and has theoretical maximum value of 0.59, it is also referred to as the power coefficient of rotor or rotor efficiency.
V: is the wind velocity in m/s,
ρ: is the air density in (kg/m3) equals to 1.225kg/m^3
A: is the area swept by the rotor blades in (m^2)

B. Calculations For Solar Energy

To determine the size of PV modules, the required energy consumption must be estimated. Therefore, the power generated by pv module as in [7] is given by

Static:

$$Ps = i(t) \times As \times \eta(pv) \quad (3)$$

Where,

Ps: solar power in watts (static)
i (t): insolation at time t (w/m^2)
As: area of single PV panel (m^2)
$\eta(pv)$: overall efficiency of the PV panels .

Overall efficiency is given by,

$\eta(pv) = \sigma \times \kappa$ (4)

Where,

σ: Annual average solar radiation on tilted panels.
k: Performance ratio, coefficient for losses.

With single axis solar tracker:

$Ps' = i'(t) \times As \times \eta'(pv)$ (5)

Where,

Ps': solar power in watts (with single axis tracker)

and

$\eta'(pv) = \sigma' \times \kappa'$ (6)

Where,

η′: overall efficiency of the PV panels with single axis solar tracker

Since, by using single axis solar tracker the efficiency of solar panel is increased

Thus,

$\eta' > \eta$

Therefore $Ps' > Ps$ (7)

Therefore total power generated is given by:-

Static:

$Pt = Pw + Ps$ from equation (1)

With single axis tracker:

$Pt' = Pw + Ps'$ (8)

Equation (8) is obtained by replacing Ps of equation (1)
By Ps′ of equation (5) and hence,

$Pt' > Pt$ (9)

VII. CONCLUSION

Power generation system with single axis solar tracker is good and effective solution for increasing the energy conversion capability of solar panel and hence power generation. The use of single axis solar tracker along with solar-wind hybrid power generation results in increased efficiency and hence more power generation to meet the increasing load demand with the presently installed plants. These type of power plants can be used in remote and hilly areas where it is impossible to lay down transmission networks. This effectively reduces transmission cost to a high extent. Also the presence of wind and solar radiation in ample quantity adds to the generation.

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