HYBRID RENEWABLE ENERGY SYSTEM: A REVIEW

[1]Jagdeep Singh, [2]Mohit Jambu, [3]Kulvir Singh, [4]Sahil Syal

[1]Assistant Professor, [2]Assistant Professor , [3]Assistant Professor, [4]B.Tech Student
[1]Department of Automation & Robotics Engineering,
[1]Gulzar Group of Institutes, Ludhiana, India.

Abstract: The requirement of electrical energy is increasing in domestic as well as industrial applications. To meet the necessity of energy more resources are needed and furthermore environmental health should be taken care of. Due to use of conventional sources such as petroleum and coal, environment is debasing. As electric energy is the most reliable source of energy, generation of electric energy by using natural or non-conventional resources such as wind and solar energy is necessary. For generating more and more energy these resources should be used in efficient and smart manner. For that purpose this paper proposes a review of using hybrid of solar tracker and vertical wind mill**.**

Index Terms **– Solar tracker, wind mill, LDR, Geared stepper motor, microcontroller.**

I. INTRODUCTION

Utilization and requirement of energy is rapidly goes on increasing with increment in populace of nation. Individuals use the energy resources like oil, gas and coal to satisfy their basic needs. These sources of energy are very limited , costly and makes contamination in the earth environment. These sources of energy are not recoverable so there is a need to use natural as well as renewable sources like solar energy, wind energy, geothermal energy, tidal wave energy etc. The earth receives several hundred units of solar energy per year, which is enough for the requirement of human. Solar power generation system using some tracking mechanism is an efficient way to utilize the major part of available solar energy. As the sun is revolving around the earth, solar energy is not constant at any specific direction in a whole day. It is necessary to track the sun in each direction to increase the efficiency of solar energy.[4] A solar tracker is a sensory device built with the solar panel which follow motion of the sun and moves the solar panel according to that motion of the sun, ensuring that the maximum amount of sunlight strikes on the solar panels throughout the day.[2] After finding the sunlight, the tracker tries to navigate through the path ensuring the most part of sunlight is detected. In market, single-axis and two axis tracking systems are available. Previous researchers used single axis tracking system which follows only the Sun's east-west movement.[3] But the earth has two types of motion, the daily motion and the annual motion. The daily motion causes the sun to appear in east to west direction over the earth whereas the annual motion causes the sun to tilt at angle of 23.5° while moving along east-west direction [4]. So the solar panel application is not effectively used when we are using single axis tracking system. To track the sun movement accurately dual axis tracking system is necessary[4]. Light dependent resistor (LDR) can be used as sensor for this system. The resistance of LDR decreases with increasing light intensity [4]. Two dual Op-amps can be used as comparator for comparing the light intensity. Diodes can be used for filtering the negative voltages coming from the comparators. Microcontroller generates the suitable control signals to move the solar panel in the proper direction. But the microcontroller output ranges from 0 to 5 volt [2][5]. So to increase the voltage and current level motor driver can be used. Two 12 volt full geared stepper motors can be used here for rotating the solar panel in two different axes.[12]

II. WIND TURBINES

There are generally two different types of wind turbines. One type is built with the aim of generating electricity from wind with high speeds. On the other hand, the other type is built especially for areas with low wind speeds, such as Malaysia. Wind turbines consist of a set of blades attached to a rotor hub, which together form the rotor; this rotor deflects the airflow, which creates a force on the blades, which in turn produces a torque on the shaft such and the rotor rotates around a horizontal axis, which is mainly attached to a gearbox and generator. These are inside the nacelle, which is located at the top end of the tower, along with several other electrical parts. The generator generates electricity, which is moved down from the tower and out to an available transformer.[8]

2.1 HORIZONTAL AXIS WIND TURBINES (HAWT)

HAWT consists of blades that extract wind energy on horizontal axis and are parallel to the ground. By facing the wind flow perpendicularly, the blades work and turn due to aerodynamic lift. HAWT is the most popular choice of wind turbine. HAWT have a greater efficiency then VAWT when extracting energy from the wind force due to its design that allows it to extract the energy through the full rotation of the blades when placed under consistent wind flow. It is also immune to backtracking effect [9]. However, HAWT has a major disadvantage, which is the fact that it must always be pointed in the wind direction to work efficiently.

2.2 VERTICAL AXIS WIND TURBINES (VAWT)

VAWT rotate perpendicularly to the ground and around the vertical axis. This type of turbine utilizes drag or lift or a combination of the two to operate. There are generally two main designs of VAWT and both designs work on different principles. The first design is Savonius that uses drag forces to work just like a water wheel and the other design is Darrieus that uses aerodynamic blade to generate lift and turn the turbine. VAWT is omnidirectional and can receive wind from any direction [9]. VAWT is the best choice to be installed in the slow and more turbulent wind environment such as urban areas because it can generally start to produce power at such low wind speed. The system for VAWT such as gearbox and other equipment can be

packed together and installed closer to the ground, hence eliminating the need for extra cost for maintenance and making it easier to be controlled.

VAWT are quieter than HAWT, However, the disadvantage of VAWT also cannot be ignored easily. VAWT is inefficient in high speed wind environment because it has very low starting torques and issues on its dynamic stability.

It should be noted that both have their own advantages and disadvantages, as discussed above. Out of these turbine the primary focus of this paper is Vertical Axis Wind Turbine (VAWT). VAWT can operate in flows coming from any direction, and take up much less space than a traditional HAWT . VAWT are definitely a credible source of energy for the future [7]. VAWTs advantages like 1)Its construction is simple. 2) Low cost, simplicity reduces cost of construction. 3) They can accept wind from any direction, thus eliminating the need for re-orienting towards the wind can't be ignored. VAWT can work better where there is low wind strength or constant winds, VAWTs constitutes of drag-type configuration, such as the Savonius rotor, and a lift-type configuration, such as the Darrieus rotor [9].

Fig. 1: Horizontal axis wind turbine and Vertical axis wind turbine
(Source: Shutterstock)

III. SOLAR TRACKER

A solar tracker is a device made up with the solar panel and a sensor, which tracks the motion of the sun across the sky and moves the panel according to the motion of the sun, ensuring that the maximum amount of sunlight strikes on the solar panels throughout the day[2]. Sun is the natural power source. It is a renewable resource that is economical. This energy is available everywhere. Use of solar energy is getting popular as one of the important means of renewable energy resources. But most of the solar panels are fixed. As sun is a moving, this approach is not the best method. Solution for this is to use a solar tracker that will actively follow the Sun. In market, single-axis and two axis tracking systems are available[2].

3.1 Previous Research Results

The maximum power output of the static panel and tracking solar panel is 6.417 watt and 7.038 watt respectively is found at 12:00 pm which clearly shows the better efficiency of tracking solar system over static solar system. [2] Table 1 shows the power values of static and tracker solar panel. [2]

Table 1. Power values of static and tracking panel at different times in one day[2]

Time	Static panel	Tracking panel	Power gain by tracking panel
	Power (watt)	Power (watt)	
8:00 am	2.27	5.382	137 %
9:00 am	4.975	6.86	37.89%
10:0 am	5.2	6.432	23.69%
11:00 am	5.656	6.496	14.85%
12:00 pm	6.417	7.038	9.68%
1:00 pm	6.18	6.592	6.67%
2:00 pm	5.768	6.18	7.14%
3:00 pm	3.528	5.712	61.90%
4:00 pm	0.667	2.10	215.14%
5:00 pm	0.137	0.156	13.86%

The power coefficient for two blades has a noticeable increasing values than the three blades. It appears that the two blades savonius wind turbine has it highest value of (0.21) at the tip speed ratio of (0.8), the three blades has a value of (0.17) at the tip speed ratio of (0.8).[6]

IV. METHODOLOGY

In order to simplify the design process the whole system is divided into four different units. [4]. These are: light sensing unit, light comparison unit, control and movement adjustment unit.

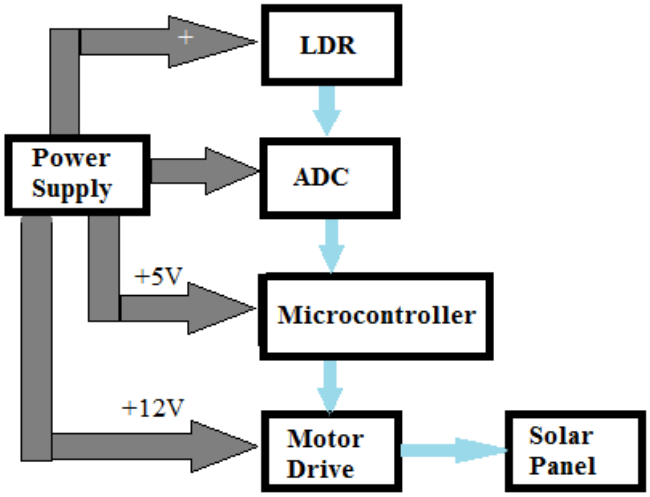

Fig. 2 Overall block diagram of the whole system

Light sensing unit consists of five sensors. Sensors are the components used for measuring light intensity and for obtaining a corresponding voltage signal. In dual axis tracking system, four light dependent resistors (LDR) are used as sensors to track the sun's exact position. Two LDR senses the position in vertical axis i.e. east and west side and other two senses the position in the horizontal axis i.e. north and south side. This signal is then passed to the light comparison unit. The remaining LDR senses the night mode and the signal is fed to the light comparison unit. A light dependent resistor (LDR) is a resistor whose resistance decreases with increasing incident light intensity[2]. The relationship between the resistance (RL) and light intensity (Lux) for a typical LDR is given in equation[2]:

$$RL=(500 / Lux)\ k\Omega.$$

For dual axis tracking system light dependent resistor (LDR) is used as sensor. Two 12 volt full geared stepper motors can be used here for rotating the solar panel in two different axes.[12] [2] In this dual axis four LDR s for detecting the light intensity can be used. To track the sun movement accurately dual axis tracking system is necessary.[16] With the sun always facing the panel, the maximum energy can be absorbed as the panel operates at its greatest efficiency.[16] The daily motion causes the sun to appear in east to west direction over the earth whereas the annual motion causes the sun to tilt at an angle of 23.5 degrees while moving along east-west direction. So the maximum efficiency of the solar panel is not being used by single axis tracking system. In this L293D can be used for converting binary data. [4]

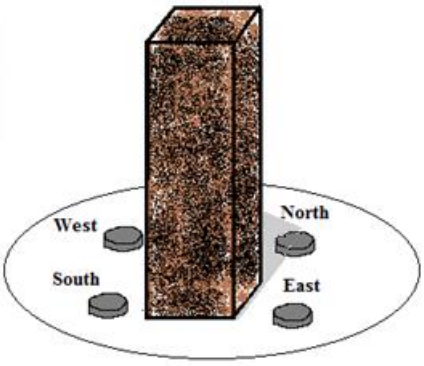

Fig. 3 Sun direction sensing arrangement with a four LDR sensor [16].

Again to minimize power consumption only one motor is given pulse at a time while the other is not. So during the change in the intensity of light in vertical axis LDRs, the panel motor rotates but base motor does not. Once the light intensity on vertical axis LDRs i.e. East and West side LDRs is equal only then the panel motor stops and base motor rotates.[2] So both the motor movement operation is vice-versa. Microcontroller is the main control unit of this whole system.[16] ATmega32 microcontroller can be used. The output from the light comparison unit comes to the input of the microcontroller which determines the direction of the movement of the motors both in the horizontal and vertical axes. [5] The design of the light sensor is based on the use of the shadow. If the PV panel is not perpendicular to the sunlight, the shadow of the cylinder will cover one or two LDRs and this causes different light intensity to be received by the sensing device.

Movement adjustment device comprises of two driver modules and two geared stepper motors. The output from microcontroller is sent to the driver circuit which executes the proper sequence to turn the stepper motors in the required direction. As the output of microcontroller ranges between 0-5 volts so it is impossible to drive a 12v motor with this voltage range. Motor drivers are placed after microcontroller to step up the signal level in a suitable value for driving the motors.

Wind turbine- Savona's turbines are one of the simplest turbines. Aerodynamically, they are drag-type devices, consisting of two or three blades (vertical – half cylinders).[8][6] A two blades Savona's wind turbine would look like an "S" letter shape in cross section (figure 4). The savonius wind turbine works due to the difference in forces exert on each blade. But increasing the number of blades will increase the drag surfaces against the wind air flow and causes to increase the reverse torque that leads to decrease the net torque working on the blades of savonius wind turbine. [6] The power coefficient for two blades has a noticeable increasing values than the three blades. It appears that the two blades savonius wind turbine has it highest value of (0.21) at the tip speed ratio of (0.8), the three blades has a value of (0.17) at the tip speed ratio of (0.8). [6]

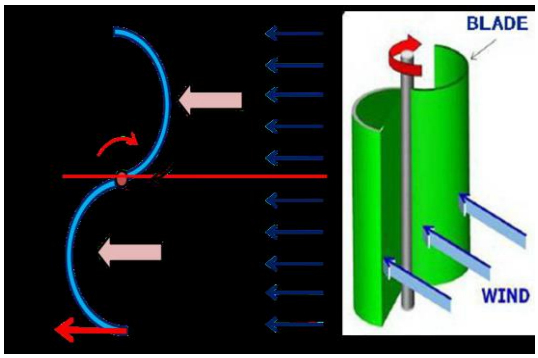

Fig. 4: Two blades Savona's wind turbine

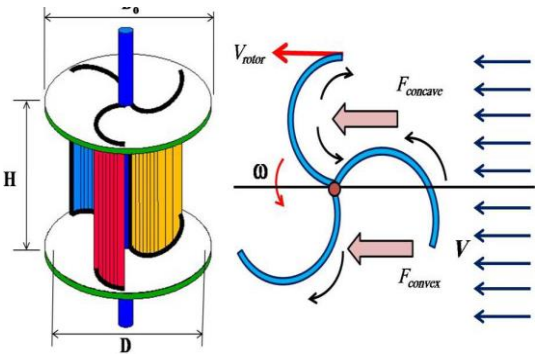

Fig. 5: Three blades Savona's wind turbine

V. CONCLUSION

Solar tracker gives better results than simple solar panel assembly as it can get more sunlight as compared to stable solar panel, so the output power developed can be increased by using solar tracker. The wind mill, specially vertical axis wind mill can be used to generate energy as it is more efficient as compared to traditional wind mills of horizontal axis of rotation as vertical axis wind turbine can be used at lower speed and having better output characteristics.

It can also be concluded that if the two sources of energy which are discussed earlier can be merged together to form a hybrid device which can generate energy at better levels than the traditional non-conventional resources the energy can be generated at high level by using the hybrid version of both the devices that is solar tracker and vertical axis wind turbine.

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