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Hybrid Energy with Solar Tracking for Street Light

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Abstract: Conservation of energy has been necessity matter of the present time. In order to keep a check on global pollution, the use of non-conventional sources of energy has also been necessitated. To enhance the overall efficiency of solar panels by keeping them aligned along with the sun position, Solar tracking system is used nowadays. In the paper, study of solar tracking systems with solar and wind energy has been presented, along with installation of hybrid system and the tracking of sun light gives the high energy efficiency by uninterrupted power by using hybrid energy system. Basically this system involves the integration of two energy system that will give continuous power. The equipment consists of combination of photovoltaic (PV) solar-cell array, a mast mounted wind generator, storage batteries(lead-acid), an inverter used to convert direct current (DC) power to alternate current (AC) power, electrical loads, and test instruments for measuring voltages, power factors, currents and harmonic contamination data throughout the system.

Keywords: LDR, Microcontroller, Photovoltaic, Solar cells, Solar tracking, Wind energy.

1. Introduction

The test of research in renewable energy micro generation technology is the lucky combination of efficiency and urban integration. Indeed, the application field with the biggest potential is within cities where the number of small consumers is concentrated. Obviously, in this context, the acceptance of people towards the installation of new power plants becomes essential for the success of projects. The thermal power stations are causing pollution which severely affects mankind and nature. These power stations result in causing many diseases. Also the natural resources like coal, oil, radio-active materials etc. will get extinct in near future. The other existing power generating systems like Hydro-Electrical power generating plants cannot afford much power as it is season based, although it causes less pollution. Therefore, it is of great urgency to go for non-conventionalenergy resources. The most popular non-conventional energy resource is solar energy which converts solar energy or solar radiation to electricity.

The aim of this work is to design and implement a hybrid power generation system using wind energy and solar energy. Solar and wind are easily available in all conditions. The non-conventional energy resources like solar, wind can be good alternative source. Solar energy has drawback that it could not produce electrical energy in rainy and cloudy season so to overcome this drawback use wind energy resources so that any one of source fails other source will keep generating theelectricity.

Solar and wind has good advantages other than any other non-conventional energy sources. Both the energy sources have greater availability in all areas. To reduce the cost of the energy, use a solar tracker. This additional output or "gain" can be quantified as a percentage of the output of the stationary array. Gain varies significantly with latitude, climate, and the type of tracker to choose as well as the orientation of a stationary installation in the same location. Solar tracker add to the efficiency of the system, reducing its size and the cost per KWH.In the fabricated model, the Solar Street Lamp reduces electrical grid energy consumption and serves as an example to advocate for renewable energy. The Street Lamp addresses the concern for clean energy while improving the efficiency of existing systems.

2. Objectives of the works

The major objective of this research is to design a solar powered LED street light that is energy efficient using motion sensor to measure the appropriate amount of load demand required and to combine install the solar and wind energy in order to maximum generation of electricity.

This type of system can be implemented in various places such as;

- In Remote areas
- Multistoried buildings
- Schools, Street lights covering large areas.
- Off grid applications.
- Solar water heaters.

- Traffic signaling system.

3. Literature survey

Hybrid Power System Using Wind Energy and Solar Energy,Yadav andSwapneel[1],the combination of two energy resources is takes place i.e. wind and solar energy. Basically this system involves the integration of two energy system that gives continuous power output. Solar panels are used for converting solar energy and wind turbines are used for converting wind energy into electricity. This paper deals with the generation of electricityby using two sources combine which leads to generate electricity with affordable cost without damaging the nature balance.

Solar Street Light Control with Single Axis Auto - Tracker and Self - Timed Power Saver, Manisha et al.[2],presents a system where the street lights are powered by the energy harnessed by the single axis solar tracker. This system is also equipped with a Street Light Energy Saver which is designed to save energy by turning off selected streetlights late at night when traffic volume is low and manual work of switching it on and off is eliminated.

Optimization of a Small Scale Dual-Axis Solar Tracking System Using Nano-watt Technology,Jay Robert et al.[3].Solar module will be positioned first in North, East, West or South. Then, the PV array will automatically search and stop at the highest current gained by the solar cell. This will occur every 30 minutes from 6am to 6pm. In these positions the values of current, voltage and power were measured. The design focuses on different applications in a small farm setting with fan, incubator, and aquarium pump motor and lightning.

Concept of Mechanical Solar Tracking System,Rohit[4].The key feature of this new concept is the arrangement of a multiple Savonius vertical axis wind turbine into the structure itself of the post. The energy is collected by a power conversion equipment along with a storage device which ensures the lighting also during windless nights. The main application of this project is the standalone street lighting, but also a grid connected option is feasible, making the system compatible with micro grid concepts.

Solar Tracking an Efficient Method of Improving Solar Plant Efficiency,Sanju Saini et al.[5]. The Study of various types of solar tracking systems has been presented. In addition a new scheme of efficient street light system using single axis solar tracking with 89S51 microcontroller has been proposed. Photovoltaic systems using solar panels are commonly used for this purpose. To enhance the overall efficiency of solar panels by keeping them aligned along with the sun position by Solar tracking system.

4. Working principle

The model is designed with components of solar panels, light dependent resistor (LDR), amplifier, analog to digital convertor (ADC), micro-controller and driver circuit along with motor.

The pole is made up of cast iron, at the top of the pole the sail type wind blade is attached which is attached with dynamo and wind turbine. The blades are made of unsaturated polyester, fiber-reinforced epoxy composite material sail type design. The wind turbine having a sail type blade is capable of rotating about 360 degree. The movement of wind turbine is based on the two small spur gear attached with dynamo.Then the solar panel is attached below of wind blade adjustment. Solar panel consists of number of silicon cells, when sun light falls on this panel it generate the voltage signals then these voltage signals given to charging circuit. Two LDR sensors are attached at the end of panel and the panel is attached with gear mechanism for tracking the direction of sun. The worm gear arrangement is attached along with motor and sensor and order to achieve the movement of the panel with the direction of sun.

The base where panel is fixed is having two limiting switches. A limit switch with a roller-lever operator is installed on a gate on a canal lock and indicates the position of a gate to a control system.Two ball bearings are attached at the end of the tracking which helps for supporting the tracking devices. The ball bearing is a type of rolling-element bearing that uses the balls to maintain the separation between the bearing races. Fig.1shows the working of solar tracking system which consists of solar panel, LDR sensor, control unit, motor and battery as a main parts.

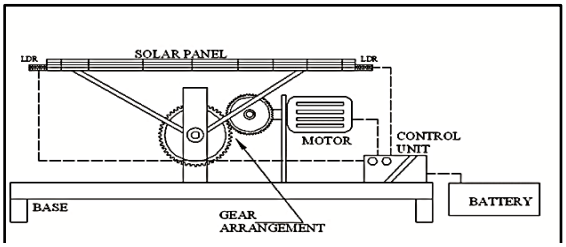

Fig.1 working of solar tracking system

CFL bulb is attached at the below of panel. Then at bottom of the pole charge controller and battery is attached. The capacity of charge controller is 24 volt. There are two batteries. The 12 volt battery is connected with tracking mechanism as well as with solar power. The power stored in this battery is used to run the tracking mechanism. This battery is get charged by solar power. One more battery is of 6 volt battery which is connected with the led lamp. This battery stores the power that are received from the bothwind and solar power. Thus stored power is utilized to lighten the pole light. Fig.2 shows the working of hybrid system.

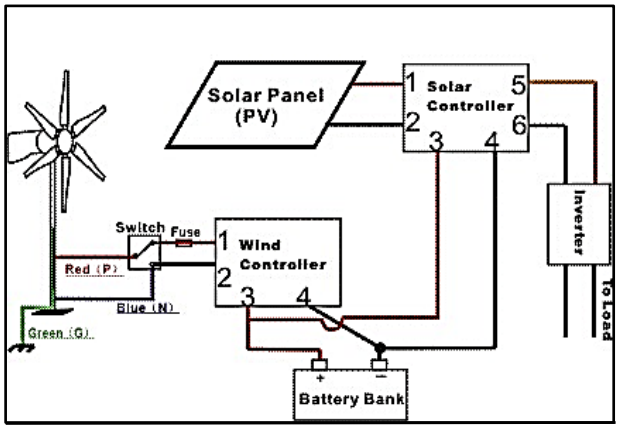

Fig.2 working of hybrid system

The microcontroller used is the flash type reprogrammable microcontroller in which already programmed. Microcontroller receives two digital signals from the ADC and compares that signal. The controller is having 40 pins and 5 ports. The controlling system mainly consists of the resister array which is of 1 kilo ohm resister, disc capacitor to regulate the voltage which is of 10 kilo ohm capacitance, reset bottom, electrostatic capacitor which is used for the filtering purpose.

5. Components used in model

The fabricated model consists of

- Solar panel and solar cells
- Sun light tracking system
- Wind turbine
- Microcontroller, control system, switches and dynamo
- Worm gear and spur gear arrangements
- Battery
- LDR sensor
- Charge controller

5.1 Solar panel and solar cells

Solar energy is a large inexhaustible source. A solar power technology that uses solar cells or solar photovoltaic arrays to convert light from the sun directly into electricity. Photovoltaic is in which light is converted into electrical power. It is best known as a method for generating solar power by using solar cells packaged in photovoltaic modules, often electrically connected in multiples as solar photovoltaic arrays to convert energy from the sun into electricity.

5.2 Sun light tracking system

A solar tracker will track the sun throughout the day and adjust the angle of the solar panel to make the sun normal to the solar panels at all times. The orientation of the solar panels may increase the efficiency of the conversion system from 20% up to 50%. The sun tracking solar power system is a mechatronic system that integrates electrical and mechanical systems, and computer hardware and software. The provision of sensor make the solar panel to move in the direction of sun. The two LDR sensors are attached at the end which are programmed which will detects the sun light.

5.3 Wind turbine

A wind turbine is a rotating machine which converts the kinetic energy in wind into mechanical energy.Sivaramakrishna and Ch.Kasi Ramakrishna Reddy [6], Hybrid Power Generation through combined solar–wind power and modified solar panel.If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill. If the mechanical energy is then converted to electricity, the machine is called as wind generator or wind turbine. In the fabricated model, the wind turbine use is of sail type. The reason behind choosing such type of wind turbine is that it can rotate 360 degree. Is helps to convert more amount of kinetic energy in electrical energy. The wind mill setup model as shown in Fig. 3.

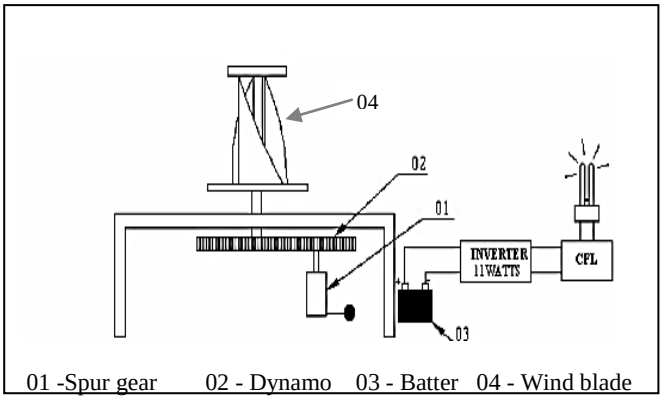

Fig. 3wind mill setup

Vertical axis wind turbine (VAWT) have the main rotor shaft arranged vertically. Key advantages of this arrangement are that the turbine does not need to be pointed into the wind to be effective. This is an advantage on sites where the wind direction is highly variable, doesn't need to support it, and it is more accessible for maintenance.However VAWT has more area of contact with wind flow hence it is more advantageous than horizontal axis wind turbine (HAWT).

5.4 Microcontroller, control system, switches and dynamo

Microcontroller is a general purpose device, which integrates a number of the components of a microprocessor system on to single chip. It has inbuilt CPU, memory and peripherals to make it as a mini computer.

Control unit:In the fabricated model the main device is a micro controller is used to control the whole unit of the model. The micro controller is connected to the control unit. The control unitis connected with the battery to get the power supply. The tracking of sun is reprogramed and connected with the microcontrollersFig. 4shows block diagram of control unit.

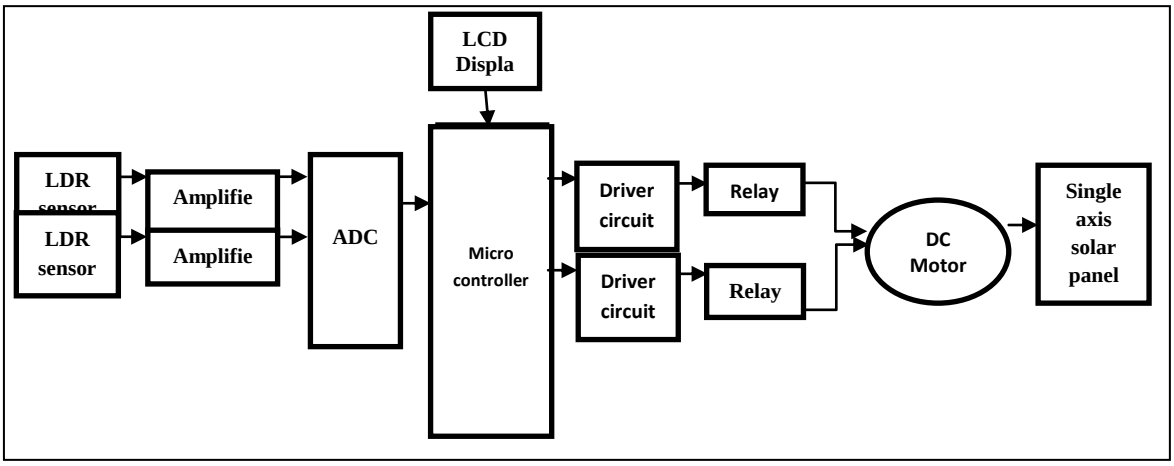

Fig. 4block diagram of control unit

Relay switches:A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. AdarshAdepp [7],solar tracker with stepper motor control. The coil current can be on or off so relays have two switch positions and they are

double throwchangeover switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. Fig.5 shows relay switches.

Inverter: An AC load can be powered from a DC source by using a converter to change DC to AC. This circuit is designed for taking 230V AC from the 12V DC input. An AC load can be powered from a DC source by using a converter to change DC to AC. The wattage of output depends on these three equipment. A DC-to-AC inverter energized from a 12-volt DC input signal uses a single stage inverter circuit to produce a quasi-sine wave output signal.

DC motor: In any electric motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, it will experience aforce proportional to the current in the conductor, and to the strength of the external magnetic field. The internal configuration of a DC motor is designed to harness the magnetic interaction between a current-carrying conductor and an external magnetic field to generate rotational motion.

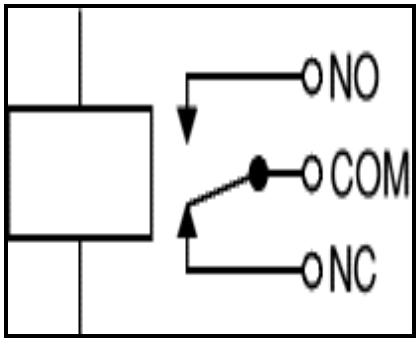

Fig. 5relay switches

5.5 Worm gear and spur gear arrangements

A worm gear is type of mechanical gear. Worm gears are used when large gear reductions are needed. It is common for worm gears to have reductions of 20:1, and even up to 300:1 or greater. Many worm gears have an interesting property that no other gear set has the worm can easily turn the gear, but the gear cannot turn the worm. This is because the angle on the worm is so shallow that when the gear tries to spin it, the friction between the gear and the worm holds the worm in place. A gear consisting of a spirally threaded shaft and a wheel with marginal teeth that meshes into it. High overload capacity and Stable transmission with reduced vibration and noise.

5.6 Battery

Battery is one or more electrochemical cells, which store chemical energy and make it available as electric current. There are two types of batteries, primary (disposable) and secondary (rechargeable), both of which convert chemical energy to electrical energy.Ashish andBhushan [8], Hybrid power generation system using wind energy and solar energy.Primary batteries can only be used once because they use up their chemicals in an irreversible reaction. Secondary batteries can be recharged because the chemical reactions they use are reversible; they are recharged by running a charging current through the battery, but in the opposite direction of the discharge current. Secondary, also called rechargeable batteries can be charged and discharged many times before wearing out.

5.7 LDR sensor

A photo resistor or light dependent resistor is a resistor whose resistance decreases with increasing incident light intensity which is made up of high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron conduct electricity, thereby lowering resistance.

5.8 Charge controller

The role of a charge controller is to manage the current flow to the system, batteries and load by collecting information on the battery voltage and knowing the maximum and minimum values acceptable for the battery voltage. Generally, during normal operating condition the battery voltage fluctuates between maximum and minimum voltages. Overcharge or over-discharge condition, which occur when the battery voltage reaches some critical values.

6. Design calculation

In the fabricated model, to calculate the total amount of power generation it requires to calculate the power from wind and solar energyseparately. The combined of these two gives the total power. The amount of power generation from solar depends on the size of the panel and the weather condition. The swept of wind blade can be calculated by using eqn. (1) and power generated from wind energy can be calculated by using eqn. (2). The intensity of wind power depends on the velocity of wind.

6.1 Wind power calculations

Thickness of wind blade (t) = 0.001m
Height of wind turbine (h) =0.48m
Diameter of base of wind turbine blade (d) = 0.37m
Radius of the base of wind turbine blade (r) = 0.185m
Length of slant (l) = 0.53m

Swept Area: (A) = $\pi \times r \times l + \pi \times r^2$ (1)
= $\pi \times 0.185 \times 0.53 + \pi \times (0.185)^2 = 0.416\ m^2$

The total power generated from wind can be calculated by using eqn. (2). The generation of wind power is depend on the velocity of wind.

Wind Power: (P_W) = $\frac{1}{2} \times \rho \times A \times Cp \times V^3$ (2)

Where,
A= swept area in m^2 = 0.416 m^2
V =wind speed, in m/s = 8.1 m/s
ρ=air density=1.23 kg/m^3
Power generated from wind energy= 54.25Watts

6.2 Solar panel specifications

Dimensions = (0.32 x 0.18 x 0.025) – (L x W x D in meters)
Maximum Power (Pmax) = 15watts
Maximum Power Voltage = 12 volts
Open Circuit Voltage (Voc) = 10.8 volts
Short Circuit Current (Isc) = 0.57amp
Cells – 36
Cell Technology - Polycrystalline
Cell Shape – Rectangular
Therefore, the intensity of solar panel = 15 watts
Since, solar tracking is attached with solar panel the fabricated system increase around 30-40% of net power as that of normal panel without tracking.It is given by eqn. (3).
Solar power generation with tracking: (Ps) = Pmax + 30% of Pmax (3)
= 15 + 30% of 15
= 19.5watts
Hence with the use of solar tracking nearly 5 watts more of power can be generated as that of without tracking.
Therefore, total power generated from solar energy = 20watts

6.3 Battery calculation

The capacity of battery can be determined by using eqn. (4) whereas current flow in the battery can be calculated by using eqn. (5).

Capacity of battery: (C_B) = $\frac{B_{AH}}{C_I}$ (4)
= $\frac{8\ \text{Ah (Amp hour)}}{420\ \text{m A}}$ = 19 hrs.
Power: (P_B) = 18 w
Voltage:(V) = 12v
Current: (I) = $\frac{P_B}{V}$ (5)
= $\frac{18}{12}$
= 1.5 Amps

Therefore, current flow in battery is 1.5 Amps.

7. Fabricated model

TheCAD model andfabricated modelof the present system isas shown in Fig. 6 and Fig. 7 respectively.

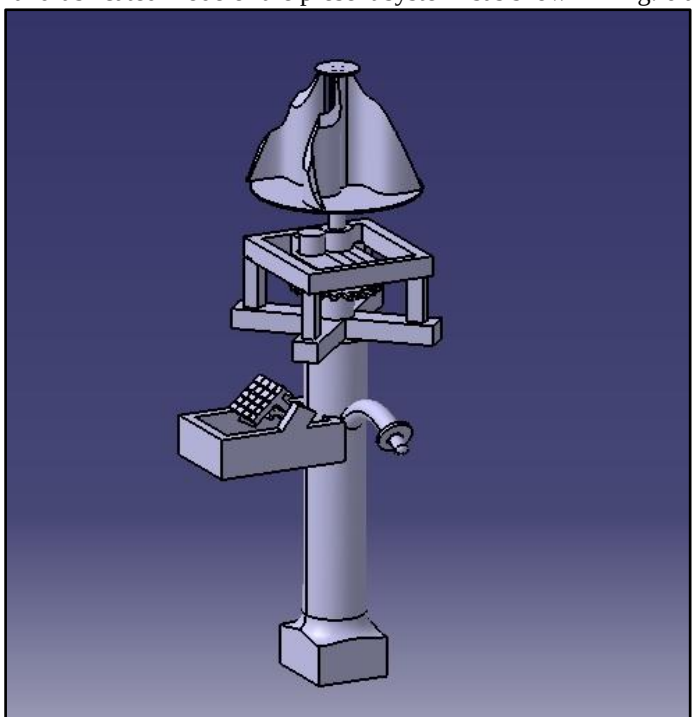

Fig. 6 CAD model

Fig. 7 fabricated model

8. Results

- The fabricated modelgives 20 watts power from solar panel which will be stored as energy in the battery. The solar energy will be depend upon the intensity of sun light falls on ground and climatic conditions.
- At the wind velocity 40 km/hrs, the turbine rotates around 45 rpm in 360 degree and generated power is stored in battery.
- The power generated from wind is nearly 54.25watts theoretically and capacity of charge controller is around 24 volt. The power generation also vary with the intensity of wind flow. The maximum intensity of wind in this area is 8.1 m/s.
- The tracking mechanism is controlled by the LDR sensor which is attached with microcontroller and relay switches and able to increase 5watts more power than without tracking.
- The power generated from solar with tracking is nearly 20watts. When the battery charged continuously for around 6 hours it gets charged fully. Then the battery gets 37 watts of power. With the help of this output able to glow a bulb of 15 watts for 3 hours.

9. Conclusion

The provision of hybrid solar-wind energy system to powerInformation Communication Technology (ICT) infrastructures, banking and hospitals in rural and the unreached communities that are not connected to National Grid Power supply system is very important so as to maintain a continuous electricity supply. In addition, further applications of this light source can be applicable to remote areas where grid power is unavailable or where area needed lighting for a short period of time. This light source technology can easily be integrated into any new or existing plans for building walkways, parking lots, and outdoor recreation facilities looking to increase sustainable energy productivity.

10. Future scope of work

- The solar tracking can be done with the time adjustment system. The solar tracking mechanism with time adjustment helps to increase efficiency of the power generation. Glass fiber reinforced plastic lighter in weight and has well tensile and has compressive strength. Hence blades would not damage and will have a longer life.
- Another improvement could be an arrangement to channelize the wind on blades.
- Another important change that can incorporate to use power controller circuit. As the input power is not constant the output power changes accordingly. Moreover there is a mismatch in the generator output and the power input to the battery. In order to rectify this problem a power controller circuit can be used.

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