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Hybrid Power Generation by Solar Tracking and Vertical Axis Wind Turbine

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Abstract:
The Solar Tracking - Vertical Axis Wind Turbine System is capable of satisfying both these requirements. In addition to being eco-friendly, it is also relatively cheaper when compared to the conventional methods of electricity generation. This turbine uses both Solar and Wind Energies to generate electricity. So, we have two efficient and inexhaustible sources for uninterrupted generation of electricity. The system has two basic components – one for generation of electricity through Solar Energy and another one for generation from Wind Energy. Even in the case of absence of either of the two sources, the other remaining source could be used to supplement the absence of the former. Due to all these features, the Solar-Vertical Axis Wind Turbines could be considered suitable for replacing the existing old means of electricity generation. Because, not only are they cheaper, but also economic and highly efficient. These turbines are gaining ground day by day and hopefully will be helpful in making us achieve the long sought-after goal of green and clean energy.

I. INTRODUCTION:
Imagining a day without electricity in today's world is equivalent to a nightmare. Since its inception in early 19th century, Electricity's relevance has changed from a mere spark for illumination to a massive driving force behind gigantic tasks. Today, Electricity has become an inseparable part of every household. It has gained as much significance as that of food and water for people. From sowing to harvesting and cooking, everything has electricity embedded within it. It his helping reduce the labor involved while doing all sorts of tasks. Thus, it has helped create a strong, unbreakable bond with humans.

Present sources of Electricity Generation:
Since the introduction of electricity, many diverse methods of producing electricity have evolved. Some of them are as follows:

a.) Thermal Energy
b.) Nuclear Energy
c.) Wave Energy
d.) Hydro Energy
e.) Solar Energy
f.) Wind Energy

In India, the above mentioned resources are used in varied proportions for the sake of producing Electricity. However, Fossil Fuels still contribute to a major amount of Electricity generated in India.

Environmental Concerns:
All energy conversion methods used to produce electricity have some environmental impact. The impact may have an active effect like the emission of airborne pollutants, or may have a passive effect like aesthetics or habitat modification. For example, Coal mining, particularly surface mining, has both long-term and short-term effects on land, including dust,

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noise, and water drainage/runoff. Preparation of coal produces both solid and liquid waste of which must be treated and disposed. Transportation of coal produces dust while coal storage produces dust to control and also results in water runoff problems. Not only does the final production of electricity have an environmental impact. The transmission of electricity with concerns over electromagnetic fields, aesthetics, and land use, also impacts the environment. Understanding these concerns, we have come to a conclusion that dependence on fossil fuels and other conventional sources for the production of electricity are not only hazardous to environment but are also really inefficient and expensive. So, there needs to be a shift from fossil fuels to renewable sources for the sake of producing electricity through cleaner means. So, in order to reduce these woes, we have come up with the Hybrid Solar Tracking Vertical Axis Wind Turbine. It is not only eco-friendly, but also quite economical. It is the one that is capable of sorting out almost all the woes that we have with conventional sources.

II. HYBRID POWER GENERATION SYSTEM

Combination of different but complementary energy generation systems based on renewable energies or mixed is known as hybrid system. Hybrid energy system is the combination of two energy sources (Solar and Wind Energies) for giving power to the load. In other word it can defined as "Energy system which is fabricated or designed to extract power by using two energy sources is called as the hybrid energy system." It has the following structure:

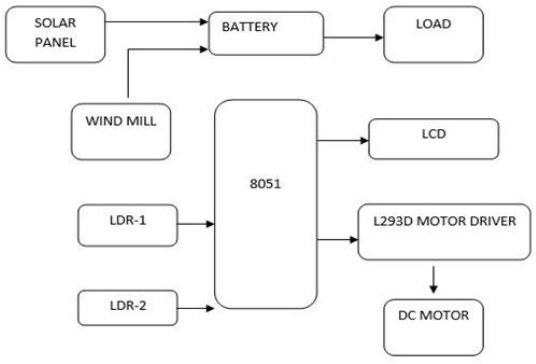

Fig 1: Layout of Hybrid Power Generation System

In the given system, the sources used are Solar and Wind energies which are harnessed simultaneously to generate power. A combination of both these energies means, there is always a backup whenever one of these sources is unavailable due to some circumstances. Also, the system uses the technique of Solar Tracking in order to maintain constant rate of electricity generation through Solar Energy. In addition to Solar and Wind systems, the Solar tracking device also contributes to electricity by the virtue of its working mechanism.

Main Components of Hybrid Power Generation System:

The system is divided into three main components which generate power separately from each other. They are:

1. Solar Power Generation Unit
2. Solar Tracking Unit
3. Wind Power Generation Unit

These are explained below:

Solar Power Generation Unit:

The Solar Power Generation Unit of Hybrid power generation system uses Solar Energy to generate power. In this type of setup, the Solar Panel is used for producing electricity by the virtue of "Photo-Voltaic Effect".

Setup and Working Principle

The setup for the unit is a very basic one. It consists of a **Solar PV Panel** which takes in the incoming solar radiation and converts it into electricity through the "Photovoltaic Effect".

The generated electricity is then sent to the battery where it is stored for further use. **Photo Diodes** are used in the pathway in order to prevent back emf whereas **resistors** are used to maintain uniformity of flow. **LED indicators** can be used to show the passage of electricity through a particular point.

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Solar Tracking Unit:

The Solar Tracking Unit is connected to the control unit which constantly monitors and sends commands to control the functioning of the unit. Even the Solar Tracking system is capable of producing electricity. The continuous modification of the sun-earth relative position determines a continuously changing of incident radiation on a fixed PV panel. The point of maximum received energy is reached when the direction of solar radiation is perpendicular on the panel surface. Thus an increase of the output energy of a given PV panel can be obtained by mounting the panel on a solar tracking device that follows the sun trajectory.

Setup:

The Solar Tracking System consists of the following important components:

a. Light dependent resistor
b. Micro-controller
c. Output mechanical transducer (stepper motor)

Light Dependent Resistor:

Light Dependent Resistor is made of a high-resistance semiconductor. It can also be referred to as a photoconductor. If light falling on the device is of the high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron conducts electricity, thereby lowering resistance.

Micro-controller:

This is the location from where the tracking is controlled. It has components like control unit for assessing the direction of sunlight and issuing commands, the Drive-Unit for carrying forward the command to align the solar panel in the correct direction.

Output mechanical transducer (Stepper Motor):

A DC stepper motor is used in this system to align the solar panel after tracking process.

A DC Motor is a rotary electrical machine that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. One more benefit by the use of DC Motor is that, electricity can be generated by coupling its moving shaft with a generator. This is the method through which this system generates electricity.

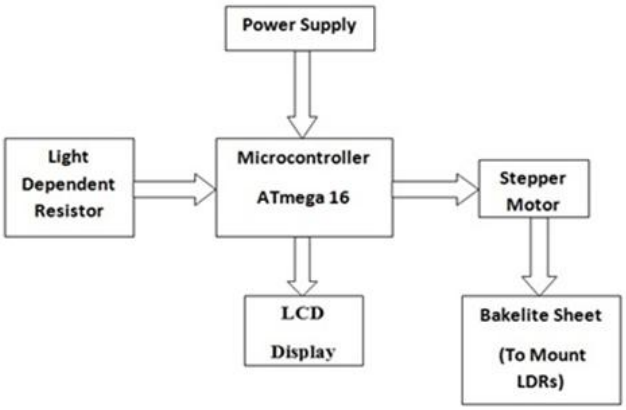

Fig 2: Block Diagram of Solar Tracking System

Working:

At the beginning, the sunlight falls upon the Light Dependent Resistors (LDRs), which sense the sunlight and transfer this information to the Control unit. The control unit assesses this sunlight and issues command to align the solar panel in the correct direction. This command is transferred to the drive-unit which executes the command by making the DC Stepper Motor to move the Solar Panel to the correct position. There is also a DC Generator coupled with the shaft of the stepper motor. Whenever this shaft moves, the generator generates electricity by the virtue of Mechanical power.

Wind Power Generation Unit

In this component of Hybrid Power Generation System, the electricity is generated by the virtue of the power of wind. The main component of this system is the wind turbine, in which, the mechanical energy is converted into electricity.

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Vertical Axis Wind Turbine has been used in this project, considering its operational and structural advantages over the Horizontal Axis Wind Turbine.

III. CALCULATIONS, TESTS AND RESULTS

Power Generated by Solar Power Generation Unit:

Capacity of Unit: 10 W/h
Volts: 12V
Period for which Solar Panel is exposed to Sun in summer (T_s): 9 hrs
Period for which Solar Panel is exposed to Sun in winter (T_w): 7hrs
Total Power per Day (P_s): 90W /day
If Losses are included,
(The rated power of Solar Panel* the no. of hrs of Sunshine* Dust, Weak Radiation * Efficiency of Charge Controller)
Power (P_s) = 10*9*0.90*0.85= 64.8Watts/Day
The power generated by the solar unit (including losses) lies within the range of the power that has been obtained in the calculations. Power generated is different for each and every hour. It basically depends upon the time of the day and the solar irradiance at that particular time. By ascertaining the magnitude of power generated with the help of calculations, efforts can be made in order to improve the power generation ability of the solar panel unit.

Power Generated by Solar Tracking Unit:

DC Motor Capacity: 0.002 HP
Volts (V_{st}): 5V
Speed (N_{st}): 10 RPM

Multi meter Readings:

Current (I_{st}) = 0.2Amp/hrs
Power (P_{st}) =V_{st}*I_{st} =5 V* 0.2 Amps
Power Generated (P_{st}) =1W
This is the power that is generated during the tracking process. The rotation of DC Generator contributes to EMF which eventually leads to current flow.

Power Generated by Wind Power Generation Unit:

Kinetic Energy of Wind:

$P=1/2*\rho*A*V^3$
(P=Power, ρ=density, A= swift area, V= velocity of wind)
$p = 1/2 * 1.125 *0.04575 * 5^3 = 3.21$ kg m^2/s^3

Multi meter Reading:

I = 0.2 amps/min
Power (P) = V*I=12*0.2
Power (P) =2.4 W/min (if Wind Flow is continuous and V =5 m/s)

IV. SETUP AND WORKING

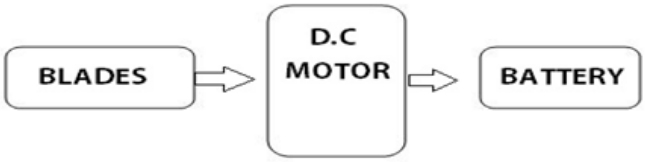

Fig 3: Block Diagram of Wind Power Generation System

The setup consists of a Vertical Axis Wind Turbine (V.A.W.T) installed for harnessing the energy of wind. A D.C Generator is connected to the turbine which generates electricity by converting the mechanical energy of the moving blades into electricity. This converted power is sent to the battery where it is stored for future use.

Hybrid Power Generation System

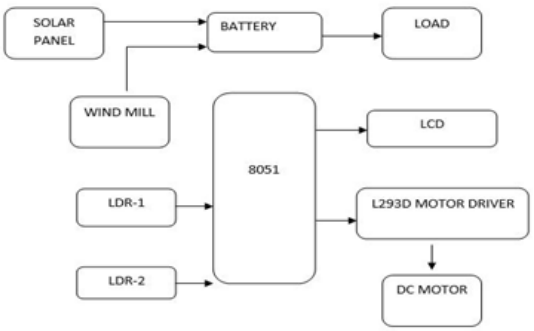

Fig 4: Hybrid Power Generation System

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When all the above mentioned components i.e. Solar Power Generation Unit, Solar Tracking Unit and Wind Power Generation Unit are combined to form a single power generation unit, it is called as Hybrid Power Generation Unit. It consists of all these three components which simultaneously produce power. The generated power is stored in a battery which is then used to power any electrical appliance (a light bulb in our case).

Field Analysis of Project under Real Time Conditions:

Real Time field analysis of the Hybrid Solar Wind Power Generation System to assess its performance was conducted in Malakpet area of Hyderabad. Under this assessment, we have carried out separate, full-scale tests upon both solar and wind components of the hybrid system. They are explained below.

Fig 5: Working Setup

Working Analysis for Solar Power Generation Unit:

For assessing the ability to generate solar power, the solar unit is placed under sun throughout the day. It is initiated under nil battery condition. For the first hour, it accepts solar energy and generated power. This power is simultaneously stored in the battery. The solar power generated during this hour is noted down. In the next hour, the battery is completely drained such that the charge becomes nil again. This is done so as to separately determine power generated in each respective hour. The same method of alternately charging and discharging battery and noting down the power generated whilst charging for each respective hour is followed. The results are plotted in the form of a bar graph shown below (in fig 6).

Working Analysis of Wind Power Generation Unit:

For analyzing the performance of the wind power generation unit, the same procedure carried out for assessing the solar unit is followed. In the first hour, the turbine is made to rotate and generate power and, in the next hour, the battery is completely discharged. This procedure is repeated and the values of power generated for each respective hour are noted down. This data is represented along with the solar data in the form of a bar chart shown below (Fig 6).

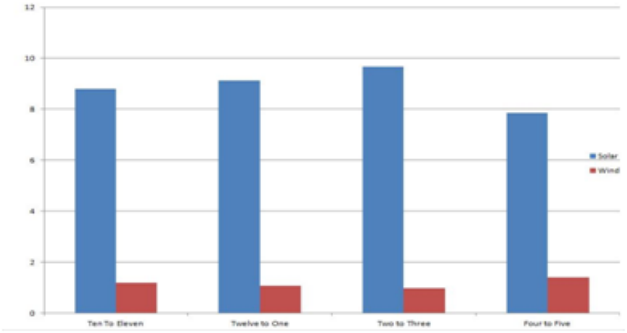

Fig 6: Power Generated/Hour (Blue-Solar, Red-Wind)

Observation from Test

From this test, it is observed that the average power generated in an hour (either by solar or wind unit) is very much sufficient to light up a bulb of 15W for about 45-50 minutes. The time period can vary according to the state of sunshine or wind flow. Also, the time taken to completely fill up a battery varies according to the availability of Sun and Wind. The more the availability of Sun and Wind, the less is the time taken to fill a battery to full capacity. Thus, the Hybrid Power Generation System stands out as a very reliable and efficient setup to generate power.

V. CONCLUSION

Some of the aspects of Hybrid Power Generation System which make it special are:

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- It uses a combination of two sources. So, one source can compensate the absence of other source and continue generating power.
- There is less scope for an abrupt halt in power generation.
- It is very eco-friendly and highly sustainable.
- This system requires comparatively less investment and hence, is very economical.
- Can play a very decisive role in the quest to reduce carbon footprint.
- This system is quite useful for backward, rural areas which face severe shortage of electricity but have abundant solar and wind energy.
- It is easy to transport and install this system.
- The working mechanism is not very complicated.
- Maintenance of maximum irradiance and constant power generation due to solar tracking system.
- It has several applications in farming sector.
- This system can also be installed atop buildings so as to meet the minor power requirements.

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