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Design and Fabrication of Hybrid Street Light System

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Abstract: The Wind energy and solar energy both are non- conventional forms of energy and it is available in affluence. Electricity can be generated with the help of vertical axis wind turbine. This project aims of utilizing this wind energy in most effective manner to get the maximum electric output, and therefore we selected highway as our installation site where we can take the advantage of the moving vehicles on both the sides of the road. In the present work, turbine is design and fabricated as per the specifications. The complete wind speed survey is conducted by using anemometer. The solar energy is utilized by means of PV panels. The power developed from this hybrid system is stored in a battery and then can be used for street light, signal or toll. In this project a small model has been created for testing purpose. This project also aims for maximum output with minimum cost indulges.

Keywords: Vertical axis wind turbine, design, fabrication, solar panel, power production

1. INTRODUCTION

The consumption of energy is directly proportion to the progress of the humanity. With ever increasing population, improvement within the living customary of the human beings, industrialization of developing countries, the worldwide demand for energy is predicted to extend bright within the few years. The first supply of energy is fuel, but these fuel are quickly degrading in nature and is causing warming, urban pollution and air pollution which powerfully recommend that the time is currently come back to depend on the use of non-conventional and setting friendly energy sources is important for steering the worldwide energy provides towards proper path.

The primary sources of energy is fossil fuel, however finiteness of fossil fuel reveres and large scale environment degradation caused by their widespread use, global warming, air pollution, strongly suggests that harnessing of non-conventional, renewable and environment friendly energy resources is vital for steering the global energy supplies toward a sustainable path.

1.1 Renewable Forms of Energy

Renewable energy is energy that is collected from renewable resources, which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat. Renewable energy often provides energy in four important areas:

- Electricity Generation
- Air and Water Heating/Cooling
- Transportation,
- Rural (Off-Grid) Energy Services.

Renewable energy resources and significant opportunities for energy efficiency exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy and energy efficiency, and technological diversification of energy sources, would result in significant energy security and economic benefits. It would also reduce environmental pollution such as air pollution caused by burning of fossil fuels and improve public health, reduce premature mortalities due to pollution and save associated health and diseases. Renewable energy sources, that derive their energy from the sun, either directly or indirectly, such as hydro and wind, are expected to be capable of supplying humanity energy for almost another 1 billion years.

1.2 Wind Energy and Solar Energy Harvesting

When the wind passes through the blades of a HAWT, all of them contribute to energy production. When the wind passes through a VAWT, only a fraction of the blades generates torque while the other parts

merely 'go along for the ride'. The result is comparably reduced efficiency in power generation. Getting high efficiency from small scale VAWT is somewhat difficult. It is because of the performance of VAWT is very sensitive to the lift/drag ratio of the blade and it is not good in the low Reynolds number condition of small applications. There are a number of obstacles in scaling VAWTs to commercial size. The first is that they aren't as sturdy by design as a HAWT. This is because of where a HAWT carries most of its stress compared to widely-used VAWT models. At present, VAWTs don't generate enough electricity that the full-lifecycle accounting shows them to be advantageous on a cost or materials basis over HAWTs. VAWT designs have the blades much closer to the ground than HAWTs, so they are losing significant amounts of wind.

There are two main types of VAWTs called the drag driven VAWT (Savonius type) and the lift driven VAWT (Darrieus type) shown in Fig. 1.1 . The Savonius type functions similar to a water wheel that uses drag forces. On the other hand, the Darrieus type has blades similar to the HAWTs. Main rotor shaft of the VAWT is arranged vertically. The generator can be connected by using that axis shaft. The rudder is unnecessary for this type wind turbines because it accepts the wind which comes from any direction.

Thus solar energy simply means the energy derived from the Sun. This energy can be used to generate electricity and heat. For this project we'd focus mainly on electricity generated from the Sun. To convert solar energy into electricity, a device called solar cell or Photovoltaic (PV) cell is used. Once sunlight falls on the PV cell, it is converted into electric current. The electric current (direct current) is then inverted to alternating current used by electrical appliances. The electricity from the PV cells is also stored in batteries to save energy for the night or days of little sunlight.

A photovoltaic solar panel absorb sunlight as a source of energy to generate electricity. A photovoltaic (PV) module is a packaged, connected assembly of typically 6*10 photovoltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. A single solar module can produce only a limited amount of power, most installations contain multiple modules. A photovoltaic system typically includes an array of photovoltaic modules, an inverter, a battery for storage, inter connection wiring and optionally a solar tracking mechanism.

ThusThis project aims at advance development in the embedded system for energy saving street light. The current work is focus to generate green energy from renewable energy resource which Saves power and is Environmental friendly project. By using hybrid street light power generation pollution free system is obtained. By using this kind of system the global warming will be reduced.

2. LITERATURE SURVEY

Several investigations and experiments are carried out for Hybrid Energy Generation for Street Lights. Many new techniques and innovations are still going on for further developments. Some of the technical aspects are considered to carry out the current work from the following literature survey.

Bharat Raj Singh et al. [1], presents the integration of solar plant and wind energy plant. It will help in providing the uninterrupted power supply. A microcontroller ensures the optimum utilization of resources and it also increases the efficiency of the combined system as compared to the individual mode of generation. This system can be used for both industrial and domestic applications. Photovoltaic cell is a p-n junction diode which consists of two different layers of a semi-conductor material called as p and n region, n region is heavily doped and thin while p region is lightly doped and is thick. The voltage can be stepped up or stepped down with the help of a SEPIC converter which uses MOSFET switching. The microcontroller is used in the system to control the switching between the converters with the help of a driver circuit. A CUK converter is used to control the power supply of solar panels. To make the current flowing in the primary winding alternative in nature a MOSFET is triggered at alternate intervals and in this manner way we get the AC current in the primary winding of the center tapped transformer.

Sachin Y Sayais et al. [2], focuses on use of air on highway divider with the help of vertical axis wind turbine. Solar system is installed in a way that it diverts the vehicle air towards the turbine. The generator with the gear mechanism is connected to the shaft of the vertical axis wind turbine to generate electricity. The motivation of this project is to generate clean energy without pollution. Modified savonius vertical axis wind turbine is used in this model. The type of magnet used for rotor circuit is neodymium strong magnet. A valve regulated lead acid battery sometimes called sealed lead acid (SLA), gel cell, or maintenance free battery. In generator mechanism, 4 coils are used as a stator. The coils are connected in series to achieve desirable voltage from each coil. Inverter is used to convert direct current into alternating current which is used for street lighting system. The generated electricity is an alternating quantity. The output of the generator is rectified by the rectifier and stored in the battery. The position of solar plates is in inclined nature at an angle of 45°. The gel and absorbent glass mat types of VRLA can be mounted in any orientation and do not require constant

maintenance. A rotor is consisting with permanent magnet placed around the stator. The shape of this permanent magnet is a square.

Mohammed Wadi et al. [3], fuzzy based control approach is proposed to control the street lighting systems depending on solar and wind renewable energy resources. Fuzzy logic control is an efficient technique for solving complex problems with little mathematical equations. The proposed fuzzy controller is designed with MATLAB. A smart grid uses digital technology to improve reliability, security and efficiency of the electric system from large generation. The battery level range from 0 V to 50 V is considered as low level charging, from 25 V to 75 V as average level charging and from 50 V to 100 V as high level charging. This proposed system may be criticized as being expensive. Less consumption of energy is possible by using fuzzy model. In this paper, the proposed fuzzy controller consists of two inputs, the first input variable is the level of batteries which is charged by sun light and the second input variable is the wind speed level.

Aniket D Chavan et al. [4], describes the implementation of VAWT and solar panel for electricity generation from renewable energy sources that are wind energy and solar energy respectively. The VAWT (Vertical Axis Wind Turbine) worked on principle of electromagnetism has suspension system of permanent magnets instead of ball bearings used in conventional wind turbines. Electricity can be produced from the solar energy by photovoltaic solar cells. When photons from the sun are absorbed in a semi-conductor, they create electrons with higher energies than the electrons which provide the bonding in the base crystal. The photovoltaic effect can be easily described for p-n junction in semi-conductor materials of solar cells which are silicon, cadmium, sulphide/copper sulphide, gallium, arsenite. No device, however well designed, can extract all of the wind energy because the wind would have to be brought to a halt and this would prevent the passage of more air through the rotor. A 100% efficient aero generator would only be able to convert upto a maximum of around 60% of the available energy in wind into mechanical energy. Well-designed blades will typically extract 70% of the theoretical maximum. The wind turbine works on the principle of converting kinetic energy of wind into mechanical energy. To obtain the necessary suspension for wind turbine, two ring shaped Nd-Fe-B magnets are arranged at the middle of the shaft. Magnetic suspension leads to frictionless, noiseless, maintenance less and power loss less rotations of rotor over stator.

Babrekar et al. [5], presents the hybrid solar and wind energy systems for rural electrification and modernization of remote area. Wind turbines are accessible to the range of speed between cut in and cut off speeds. Horizontal axis and vertical axis turbines are the most frequently used turbines. Solar charge controller and wind controller are used to store the power in battery bank. Inverter is used to convert the generated DC load into AC load.

3. DESIGN CONSIDERATIONS FOR VAWT

3.1 Theoretical Power Calculation

Before finding the theoretical power the VAWT can deliver the amount of input energy that is the kinetic energy of the wind has to be find. The wind mill works on principle of converting kinetic energy of the wind in to mechanical energy. The k.E. of any particle is equal to the one half of its mass times the square of its velocity, or ½ mv2.

$K.E=½ mv^2.$ ……(1)

Where,

K.E = kinetic energy

m =mass

v = velocity

M is equal to Volume multiplied by its density ρ of air

Mass = ρ AV ……. (2)

Substituting eqn (2) in eqn (1) We had got,

$K E = ½ \rho AV^3$ watts.

Where,

ρ=density of air (1.225 kg/m3)

the surface area of the blade is calculated above that is

A = 0.3 Sqm

Available wind power $Pa = (½ \rho AV^3)$

Thus by the above equation it is evident that for the maximum utilization of the wind power there must be maximum swept area and velocity of air because wind power is directly proportional to the velocity and swept area ,it will not depend on density of air because it is a constant. So as to utilize the maximum power from the wind six blades are been used and the whole setup is placed on a highway to get maximum velocity air.

3.2 Betz's Law

Betz's law indicates the maximum power that can be extracted from the wind, independent of the design of a wind turbine in open flow. It was published in 1919, by the German physicist Albert Betz. The law is derived from the principles of conservation of mass and momentum of the air stream flowing through an idealized "actuator disk" that extracts energy from the wind stream. According to Betz's law, no turbine can capture more than 16/27 (59.3%) of the kinetic energy in wind. The factor 16/27 (0.593) is known as Betz's coefficient. Practical utility-scale wind turbines achieve at peak 75% to 80% of the Betz limit.

According to Betz's law, the maximum power that is possible to extract from a rotor is

$P_{max} = 16/27 \rho \times r \times h \times v^3$ ……. (3)

Where,

ρ= is the density of air,

h and r are the height and radius of the rotor and

v=is the wind speed.

As the mater of fact out of 6 blades only three blades will be experiencing the drag force of wind the above equation will be modified to

$P_{max} = 0.120 \times r \times h \times v^3$.

Trial 1 for a velocity of 5m/s

$P_{max} = 0.120 \times r \times h \times v^3$.

$P_{max} = 0.120 \times 0.102 \times 1 \times 5^3$.

$P_{max} = 4.19W$

Trial 2 for a velocity of 10m/s

$P_{max} = 0.120 \times r \times h \times v^3$.

$P_{max} = 0.120 \times 0.102 \times 1 \times 10^3$.

$P_{max} = 12.24W$

Trial 3 for a velocity of 15m/s

$P_{max} = 0.120 \times r \times h \times v^3$.

$P_{max} = 0.120 \times 0.102 \times 1 \times 15^3$.

$P_{max} = 41.31W$

From above results from betzs formula it is evident that the turbine that is designed is capable of producing good amount of power for different velocity of air .Thus even after considering all the losses while doing it practically a 6Wdynamo can run continuously if there is a constant flow of air without turbulence during the movement of air from both sides of the divider

4. METHODOLOGY

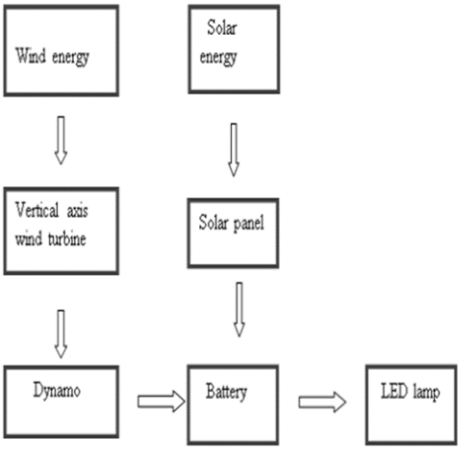

Fig. 1block diagram of hybrid street light systemg

The methodology by which the proposed project is carried out is described in the fig. 1. The proposed system has two stages as shown in Fig above. The first stage is utilization of wind energy and the second stage is utilization of solar energy. The utilization of wind energy with VAWT, dynamo, battery forms the first sub stage for the design of the hybrid street light system and the utilization of the solar energy and converting this light energy to electric current by means of PV cells and battery forms the second sub stage in the design of hybrid street light system. Thus the methodology shows the step by step procedure that has to be carried out in

the proposed project to convert the renewable sporces of energy to usefull energy well in this case to light up the street LED lamp.

5. FABRICATION OF HYBRID STREET LIGHT

5.1 Construction of Base

Considering the total weight of the vertical axis wind turbine and solar panel setup which is around 6 kg. The wind turbine support bases which is made of mild steel material is been made (steel structural ASTM A36 steel) with a (Yield Strength: 250 MPa and Tensile Strength: 400 MPa). The base was fabricated by welding. There is a supporting rod which is welded on to the base which supports the vertical axis wind turbine and on top of this vertical axis wind turbine solar panel setup is fixed.

Fig. 2 base structure

5.2 Construction of Vertical Axis Wind Turbine

The savonius type vertical axis wind turbine is been fabricated. It is a drag type device consisting of six scoops as shown in Fig.3.The scoops experience less drag when moving against the wind than when moving with the wind thus the differential drag causes the savonius turbine to spin. The turbine in our project is fabricated by bicycle wheels and PVC pipes. Initially L lamps are fixed to the bicycle wheels as shown in the Fig. 2

5.3 Assembled Hybrid System

The Fig. 3 shows the complete assembly of the hybrid system.

Fig3:assembled hybrid street light system

6. WORKING PRINCIPLE OF HYBRID STREET LIGHT SYSTEM

- At first the hybrid system is placed on the divider of an highway road Vertical axis wind turbine starts rotating due to wind flow.
- The wind flow happens due to the movement of the vehicle on both sides of the divider. Thus there is two opposite forces of wind which will act on the VAWT due to the movement of the vehicle on the highway.
- VAWT is connected to dynamo via belt drive.
- Dynamo relatively rotates with VAWT.
- Dynamo converts this mechanical energy into electrical energy.
- Meanwhile, solar panel absorbs solar energy and converts it into electrical energy.
- Battery is used to store the generated electricity. The charge controller is used for the safety od batteries
- This output power can be used to lighten the LED lamp.

7. CONCLUSIONS

The electrification using hybrid power systems are worldwide very promising in the recent years. Solar and wind power are considered as the renewable energy resources due to their high reliability and safety as well they are zero emissive. Also the nature of the hybrid power system is environmentally friendly that can be depicted from the annual emissions. Hybrid street light system can be used to generate electricity in hilly areas, where it is quite difficult to transmit electricity by conventional methods. Long life span and less maintenance are plus points. From the study of the model characteristics it is clear that this hybrid power system provides voltage stability and automatic load sharing capability. For this reason, the system is very much useful to provide good quality of power.

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