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Solar and Wind Hybrid Energy System for Street Lighting

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ABSTRACT: This paper represents the hybrid energy system using solar and wind energy sources for the control of street lighting. Solar-Wind Street light is an intelligent, small scale, and off grid LED lighting system. It's components are solar panel, wind generator system (PVC blowers), Dynamo, LDRs, battery, LED light, charge controller. The energy stored in battery during day time due to solar panel, get extracted by LEDs during the night time (because LDRs get activated due to absence of sun light). Wind also charges the batteries due to wind which is used for glowing street light. The advantage of this idea is to avoid daily running cost and make the system purely off-grid. In this prototype, we have used 12V DC system to supply energy to the lights.

KEYWORDS: High Brightness LED, Charge Controller, Photo Transistor (LDR), Solar Panel, PVC Blowers

I.INTRODUCTION

Electricity is needed for our day to day life. There are two ways of electricity generation either by conventional energy resources or by non-conventional energy resources. Electricity energy demand in the world increases so as to complete demand energy is to be generated. Now a day's electrical energy is generated by conventional energy resources like coal, diesel, nuclear etc. The main drawback of these sources is that it produces waste like ash in coal power plant, nuclear waste in nuclear power plant and taking care of this wastage is very costly. And it also damages the nature therefore sustainable energy resources needed for environment friendly energy generation. The conventional energy resources are depleting day by day. Soon it will be completely vanishes from the earth so we have to find another way to generate electricity. The new source should be reliable, pollution free and economical. The non-conventional energy resources should be good alternative energy resources for the conventional energy resources. There are many non-conventional energy resources like geothermal, tidal, wind, solar etc. the tidal energy has drawbacks like it can only implemented on sea shores. While geothermal energy needs very lager step to extract heat from earth. Solar energy and wind energy are clean, illimitable, and environmental friendly. The energy sectors were already attracted to use renewable energy in large scale. Day by day the power crisis increases in our country, the government also attracting the peoples to use renewable energy by giving 50% subsidy. Now we are in the exact time to elevate from conventional power generating system. Both sources are dependent on unpredictable factors such as climatic and weather conditions. Due to complimentary nature of our climate and also because of using both the sources we can overcome the weakness of the existing single source system. Thus we are placing both the sources near the load; it can also be called as hybrid distributed generation. This can also reduce transmission and distribution cost. The proposed system can also be used for home power generation and the capacity will depends on load requirement.

The hybrid lighting systems are self-sustaining, standalone solutions and also it reduces the transmission and distribution losses. This proposed system is supreme solutions for many applications in rural and urban areas. Solar energy has drawback that it could not produce electrical energy in rainy and cloudy season so we need to overcome this drawback we can use two energy resources so that any one of source fails other source will keep generating the electricity. And in good weather condition we can use both sources combine.

Now a day's LED based lightings are more preferred than CFLs, fluorescent and halogen lamps for street lighting, because of less power consumption, higher power factor, less carbon emission, etc., The existing solar street lighting

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system uses mono-crystalline or poly-crystalline panels and stores the energy in a lead acid battery. There will be a control system to control the battery charging and discharging. The battery should be selected depending on cost, return on investment, efficiency and cycle of operation. Influential factors such as response time (ms to hours/day), energy density (size and space requirements), environmental impact and charge time are also considered while choosing the battery. Automatic streetlight needs automatic switching ON and OFF without using manual control. The system itself detects the outside illumination level and controls the brightness of the LED. When outside illumination is very low then automatically LED is switched ON and when the outside illumination is high then the LED is switched OFF.

II.WORKING OF HYBRID SOLAR-WIND SYSTEM

Fig.1 Model of Proposed hybrid solar-wind system

A stand-alone wind system with wind system and solar PV cell is the best hybrid combination of all renewable energy systems and is most appropriate for all the applications. This combination compensate the disadvantages of each other, for example, the high wind energy production during monsoon months compensates low output generated by solar. Similarly, during winter when the wind energy is minimum solar photovoltaic takes over. The hybrid solar wind power system is as shown in fig.1.

Applications of Proposed Solar-Wind Hybrid Power System are given below

- Remote and rural area electrification,
- General lighting systems for Residential colonies and apartments.
- Street lighting

the use of proposed system the carbon emission and other harmful gases are reduced to approximately 80% to 90% in the environment.

III.DESIGN OF PROPOSED HYBRID MODEL

A. Energy storage system

The energy storage system is nothing but chemical reaction takes place in lead acid battery. The design for choosing the battery size and its calculations are given below.

Initially we have taken the load power as 10W, 12V LED light which runs for an average time of 10hours a day. Load power = 10W

For 10 hours the total power consumed by the load = 10*10 hours Total load power = 100Whr

To find the battery capacity,

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$$\text{Average AH/day} = \frac{\text{Total Load Power in \{Whr\}}}{\text{Battery Voltage}}$$

We have taken the battery voltage as 12V. Therefore the battery current as per the above calculation is 9A for an average load for 10hrs a day.
Days of autonomy = 2
Discharge limit is 50%

$$\text{Total Battery AH capacity} = \frac{\text{Average AH/day*Days of autonomy}}{\text{Discharge Limit}}$$

So the battery capacity to supply the load for 10 hours a day is 36AH. Actually we have chosen 12V batteries of 36AH from the Exide manufacturer.

B. Design of charge controller and PV module
Data required for Solar System:
1. Annual mean daily duration of Sunshine hours
2. Daily Solar Radiation horizontal (KWH/m2/day)
The installed capacity of solar power in India is only 3,744 MW while the available energy potential is 35MW / Km^2. Inability to harness the abundant renewable power sources has led to power shortage in the rural sectors.

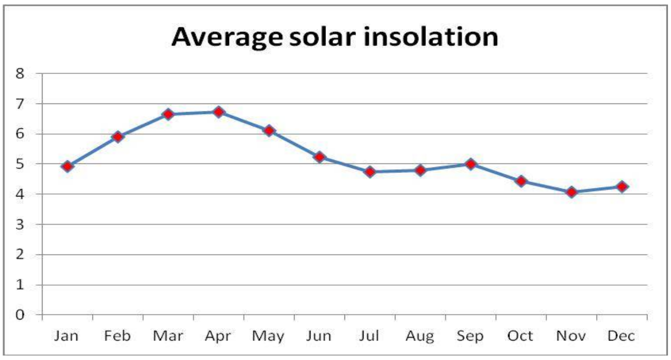

Fig.2 Average solar insolation

In this system the photovoltaic act as a voltage regulator. The primary function is to provide obstruction to the battery from being overcharged by the array. Fly-back converter is more efficient when it is used for a load less than 70W. And also it has the advantage of a voltage regulation as well as isolation. There are different types of charge controllers that can be a shunt controller, single stage controller, multistage controller or pulse controller depending upon the requirement of output power quality and protection.

For charging purpose the 12V DC battery that power the LED will be connected to the solar panels via the charge controller. The street light pole will be constructed such that it will hold the LED light.

$$\text{Input energy required to charge controller} = \frac{\text{Battery AH}}{\text{Efficiency of charge controller}}$$

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The following table shows the average solar insolation

Table-1 Average solar insolation

Month	Average solar insolation
Jan	4.93
Feb	5.89
Mar	6.64
Apr	6.72
May	6.12
Jun	5.24
Jul	4.73
Aug	4.80
Sep	5.01
Oct	4.42
Nov	4.06
Dec	4.24

So as per the above formula the charge controller should have the current rating of 111.1AH.
Calculation of PV panels and rating required are given below,

$$\text{Input required from PV module} = \frac{\text{Input of charge controller}}{\text{Number of sun shine hours}}$$

We assumed average number of sun shine hours in our country for a day is takes as 6 hours. So the required current from PV module is 19A and the number of panels required is,

$$\text{Number of panels} = \frac{\text{Required current from PV module}}{\text{Average current of a single panel}}$$

2 panels are required with the average current of a single panel is 4A.

Fig.3. Design of Solar System

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Power extracted by the wind turbine is $P_w = 0.5*A*C_P*p*v^3$
Where C_p is the power coefficient and is given by

$$C_p = \frac{\text{Power in the wind turbine}}{\text{Power in the air}}$$

The value of C_p is limited by Betz limit to 0.593
Power in the air = $P_{air} = 0.5*A*p*v^3$
Where, ρ is the air density in Kg/m^3 = 1.3
A is the area swept by the rotor in m^2
v is the wind speed in m/s
The swept area A is given by
$A = \pi r^2$
Where r is rotor blade diameter in m.

C. Wind energy system
With the advancement in the rotor designs in last few years wind power harnessing has improved exponentially. The revolution in power electronics has led to the operation at variable wind speeds and hence leads to the reduction in the generating cost.
The commonly used generators for wind energy are
1. Doubly Fed Induction generator.
2. Wound rotor induction generator.
3. Squirrel cage induction generator.
4. Permanent magnet synchronous generator.

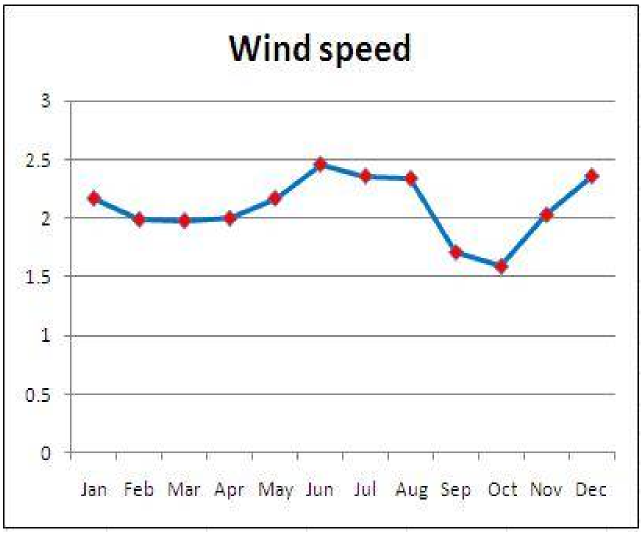

Fig 4. Wind speed (m/sec) Vs Months of a year

Electrical Power can be generated from wind using a wind turbine which converts the kinetic energy of wind to mechanical energy. Further by using generator the mechanical energy is converted to electrical energy. Since the wind is mainly non uniform the batteries are used to store power in Stand-alone Wind power generation system.
The following table shows the monthly average wind speed

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Table-2 Monthly average wind speed

Month	Average wind speed
Jan	2.17
Feb	1.99
Mar	1.98
Apr	2.00
May	2.17
Jun	2.46
Jul	2.36
Aug	2.34
Sep	1.71
Oct	1.59
Nov	2.03
Dec	2.36

As per the above table we have taken the annual average wind speed as 2.1m/s.

D. Design of wind energy system
Required terms for Wind power System:
1. Mean value of Annual Hourly speed of wind (m/sec)
2. Generated wind power from wind turbine.

The capacity of wind power that is generated in India is 7456MW. Wind plants are set up on the basis of the availability of wind speed in a particular area. When a free moving air molecule strike any object, a pressure is produced on the object. This concept enables the wind turbine to rotate. The installed capacity of wind power in India is 23,439.26 MW, but the availability of wind energy in India is 302 GW. The tapping of unexploited wind energy is the most important aspect to dwell upon so as to meet the national power demand. In a wind module wind turbine is coupled to PMBLDC generator and with a charge controller. The charge controller output is given to a battery from which DC load is feeded.

The proposed wind module components are , Wind generator (PMBLDC), charge controller, load and Batteries

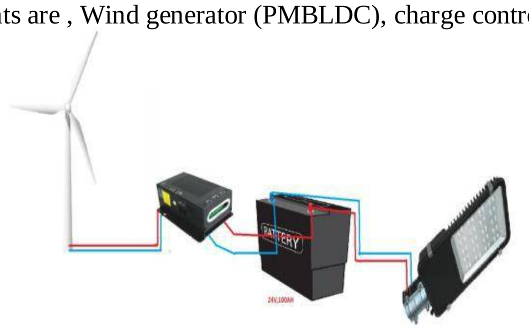

Fig.5. Design of Wind energy system

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Wind generator: The proposed solar-wind hybrid system uses a PMBLDC generator. The output of the generator is DC and which can be given to the batteries through the charge controller directly.
The size and the cost of the design is reduced due to the elimination of a rectifier, which eliminates the use of gear box and losses are reduced in the gear box.

Charge controller: The wind generator produces variable voltage when operated on variable speed. The charge controller plays a major role for regulating the generated voltage. It protects the battery from over charging. The output voltage of the charge controller is regulated by the duty cycle of the PWM signal .
To charge a 100 Ah battery, the required charge controller calculations are,

$$\text{charge controller ampere rating} = \frac{\text{total ampere hour}}{\text{efficiency of charge controller}}$$

Table -3 Specifications of wind generator

Rated Power	350W
Maximum Power	700W
Blade quantity	3
Start up wind speed	2.5m/s
Rotor blade diameter	1.7m
Rated wind speed	10m/s
Working wind speed	2.5m/s
Charging voltage	12/24V
Generator type	PMBLDC

The proposed hybrid wind-solar model is set up at latitude13.0826, longitude 80.2707, 16m above sea level.

IV. METHODOLOGY

It is important to have a well-defined and standardized frame for hybrid system based power generation for rural areas. These steps are:
a. Demand Assessment: Using accurate load forecasting of remote villages, the load demand can be fetched. Demand assessment can also be done by asking to gram pradhans, school teachers, local people, workers etc. During load survey, following factors may be considered:
1. street light demand,
2. Number of schools, commercial, houses, health centers present and the energy required by them, number of small scale industries and their energy demand,
3. Miscellaneous demand.
b. Resource Assessment: Resource assessment can be done by calculating available potential in wind, MHP, solar, Biomass, Biogas, and other renewable energy resources using data available.
c. Barriers/Constraints:
1. Annual electricity demand.
2. Employment.
3. Net Present cost.
4. Reliability.
5. Environmental factors.

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d. Demand is fulfilled by Hybrid renewable energy system. This can be done by using the combination of more than one renewable sources of energy. Some configurations are as follows:
1. Solar and wind HRES
2. PV/Wind/diesel generator HRES.
3. PV/wind/fuel cell HRES.
4. Biomass/wind/diesel generator HRES
5. PV/Wind/Biomass/fuel cell HRES

V. CALCULATIONS

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

$$TP = Ns * PS + Nw * PW$$

Where,
T_p is the total power generated
P_W is the power generated by wind turbines
P_S is the power generated by solar panels
N_w is the no of wind turbine
N_s is the no of solar panels used

VI.CONCLUSION

As discussed above the study lamp with mobile charger is successfully installed in our research lab. The future work is to reduce the cost of the working model and to make it available to the needy. Scholars should work towards making India a nation with affordable and clean energy by tapping the renewable energy assets in an ideal way. The prototype of the proposed model is made and tested for optimum output. Based on the prototype design, the real time implementation will be done at latitude13.0826, longitude 80.2707, 16m above sea level location.

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