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Design of Hybrid Streetlight System using Solar and Wind Turbine

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***Abstract*- All the conventional energy resources are exhausting. So it is necessary to shift from conventional to non-conventional energy resources. In the proposed work we have done combination of two energy sources for streetlight system. This process reviles the sustainable energy resources without damaging the nature. Basically this is a hybrid system which involves the integration of two energy system that will give continuous power. Solar panels are used for converting solar energy and wind turbines are used for converting wind energy into electricity. This electrical power can utilize for various purpose. The purpose of this proposed system is generation of electricity at affordable cost.**

Keywords- Electricity, hybrid, solar, power, wind

I. INTRODUCTION

Electricity is very much needed in our day to day life. There are two ways of electricity generation either by conventional (old) energy resources or by renewable energy resources. Electricity demand is increasing day by day with developments and new technologies. Majorly, electricity is generated by the conventional energy resources like coal, water, diesel, natural gases, nuclear energy etc. The main disadvantages of these sources is that they produce waste like ash in coal power plant, nuclear waste in nuclear power plant and taking care of this wastage is very costly and also it damages the nature. On the other side, the nuclear energy waste is very destructive to human being. The non-renewable energy resources are exhausting day by day. Soon it will be completely vanished from earth. We will have to find alternative ways to produce electricity. With the increase in global energy demand large industrial power requirements there has been a worldwide need for development in the field of renewable energy. The drastic consumption of oil, natural gas, fossil fuels and other exhaustible sources of energy at the current scenario, will lead to their depletion from earth. The concept of "sustainable development" has motivated us to search for alternative sources of energy which are freely and abundantly available to us.The non-conventional energy resources like solar, wind can be good alternative source. Solar energy has one disadvantage 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. Due to seasonal and geographical restrictions of wind and solar and weather specific usage of solar panels, the need for focusing on hybrid energy sources has received special attention.

II. HYBRID STREETLIGHT SYSEM

A hybrid energy system generally consists of two or more renewable energy sources which are used together to increase the efficiency of the system as well as greater balance in energy supply.
The Solar wind streetlight designed is an intelligent, small scale, and off-grid LED streetlight system composed of solar modules, wind turbine, backup batteries, controller and LED.
As a reliability concern, energy storage is required to have a continuous power supply and cover any deficiency in power generation from renewable energy sources. The storage system can be battery banks, fuel cell etc. with more focus on battery here.

This Hybrid streetlight system has good dependability, productivity, less emission, and is cost-effective.
Both the energy sources have greater availability in all areas. It needs lower cost. There is no need to find special location to install this system.

A. Solar Energy

Solar energy is radiant light and heat from the sun that is harnessed using range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy. Solar energy is present on the earth continuously and in ample manner. Solar energy is easily available. It is pollution free and also reasonable in cost. It also has low running cost. Only difficult part with solar system is it cannot harvest energy in bad weather condition. But it has greater productivity in all other energy sources with high initial investment. It has extensive life span and has zero emission.

B. Wind Energy

Wind energy is the energy which is extracted from wind. We have to design wind mill. It is renewable energy sources. Wind turbines convert the kinetic energy of the wind into mechanical power by rotating propeller-like blades around the rotor. The rotor turns the drive shaft, which turns on electric generator to convert mechanical power into electricity
Wind power Pw= 0.5*Þ*A*r(cube),
Where Þ= Density, A=Area swept, r=Velocity
The major drawbacks of using independent non-conventional energy resources are that unavailability of power for all time. For overcoming this we are designing solar and wind energy

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based streetlight together. So that any one source of power fails other will take care of the generation. In this proposed system we can use both sources combine. This will leads to continuity of generation. This will make system dependable. The main shortcomings of this system are that it needs high initial cost. Except that it is reliable, it has less emission. Maintenance cost is less. Life span of this system is more. Efficiency is more.

III. SYSTEM ARCHITECTURE

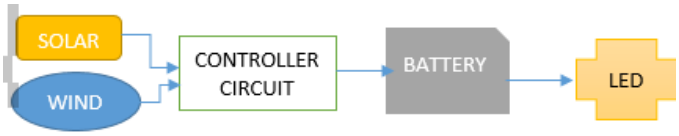

Fig.1: System Architecture

A. Simulation Design:

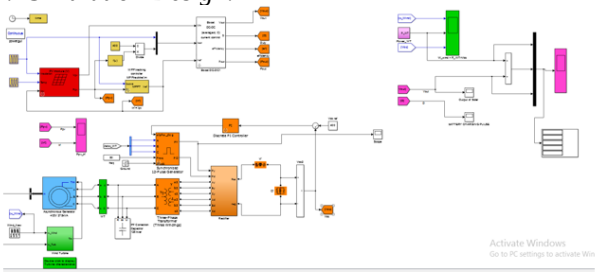

Fig.2: Matlab Simulation Design

B. Design Aspect:

A.SOLAR POLY

Solar cell is a device which convert energy of light into electricity by photovoltaic effect. The physical of PV cell is very similar to that of the classical diode with a PN junction formed by semiconductor material. When the junction absorbs light, the energy of absorbed photon is transferred to the electron-proton system of the material, creating charge carriers that are separated at the junction. The charge carriers in the junction region create a potential gradient, get accelerated under the electric field, and circulate as current through an external circuit.

Operation depends upon 3 basic attributes:

1. Absorption of light
2. The seperation of charged carriers of opposite types
3. The seperation extraction of those carriers to an external circuit.

B. WIND TURBINE

Wind turbines convert the kinetic energy of the wind into mechanical power by rotating propeller-like blades around the rotor. The design on wind turbine is based upon Solar-Mill which was developed by **WindStream** technologies.

1. Vertical axis turbine mounted on single base. Savonius wind mill accept wind from both direction
2. Silent operation
3. Cut- in speed – 5m/s

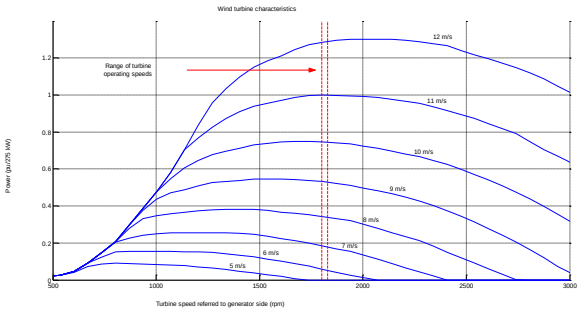

Fig.3: Wind Turbine Characteristics

Design required for Hybrid system:

A. Solar System

1. Annual duration of Sunshine hours
2. Solar Radiation (KWH/m2/day)

B. Wind System:

1. Mean Annual Hourly Wind Speed (m/sec)

The site selected is Nagpur, which has latitude of 21’14’ North and Longitude is 79’08’ East. Solar radiation data for tilted panel and average wind speed data above 50 m above the surface of Earth is taken from Nasa website.

- Average wind speed: 3.34 m/s
- Average solar radiations: 5.53 kw-hr/m2/day

IV. CALCULATIONS AND RESULTS

The total power generated by this system may be given as the addition of the power generated by the solar PV panel and power generated by the wind turbine.

Mathematically,it can be represented as

P_{total}= N*P_{wind} + N_{solar}*P_{solar}

Where,

P_{total}= Total Power Generated

P_{wind}= Power Generated by wind

N= No. of wind turbine

P_{solar}= Power Generated by Solar

N_{solar}= No. of Solar Panel

A. Calculations for wind energy

The power generated by wind energy is given by,

Power = (density of air * swept area * velocity cubed)/2

PW = ½. ρ (AW) (V) 3

Where,

P is power in watts (W)

ρ is the air density in kilograms per cubic meter (kg/m³)

AW is the swept area by air in square meters (m²)

V is the wind speed in meters per second (m/s).

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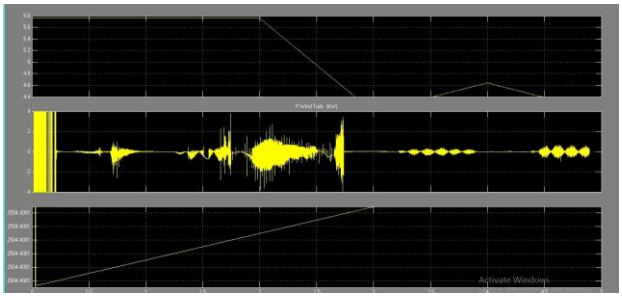

Fig.4: Matlab Wind Results

The above figure shows the total power developed by inconsistent wind and its output in DC voltage and current.

B. Calculations for solar energy

To determine the size of PV modules, the required energy consumption must be estimated. Therefore, the power is calculated as

PSolar = Ins (t) * ASolar*Effe(pv)

Where,
Ins (t)= isolation at time t (kw/ m2)
ASolar = area of single PV panel (m2)
Effepv= Overall efficiency of the PV panels.

Overall efficiency is given by,

Eff(pv)= H * PR

Where,

H = Annual average solar radiation on tilted panel.
PR = Performance ratio

CONCLUSION

Solar-wind hybrid energy systems needs only initial investment. It will compete well in generation with the conventional energy sources. When accounted for a lifetime of reduced or avoided utility costs. The cost of the system depends on the system chosen, wind resource on the site, electric costs in the area, and the battery bank required. Cost of the Wind-Solar Hybrid system is to be minimized. For minimize the cost of the system we need to increase the use of RE energy sources.

Wind-Solar hybrid streetlight will have three main advantages:

1) Social benefit: Wind-Solar hybrid streetlight is a high-tech environmentally friendly product. Installing the wind-solar hybrid streetlight is done, it gives conformity with the government's environmental protection idea.
2) Economic benefit: It uses and produces power by itself. After the construction of a one-time investment, we can get a long-lasting benefit. Changing the traditional streetlight system laid on the underground cable power supply way saves a lot of manpower and monetary investments.
3) Environmental benefit: Each traditional streetlight spends 1825 kWh power in 10 years. According to the standard thermal coal consumption (400g / kWh) to calculating, the standard coal consumption will be 7.3 tons. So a city center will consume 876,000 tons of standard coal just in 10 years, It will let out 3 million tons of carbon dioxide, 17,500 tons of sulfur dioxide, 13,000 tons of nitrogen dioxide, and so much 10powder and impurity. But when using the wind-solar hybrid streetlights, the pollution will be avoided.

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