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SOLAR-WIND HYBRID POWER GENERATION SYSTEM

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Abstract – *In today's technology driven world electricity is one of the foremost thing for our day to day life activities. As we all are oblivious of the fact that the renewable sources of energy are depleting at a lightning fast rate. So it's time for us to shift the focus from conventional to non-conventional sources of energy to produce electricity. The output of the electricity produced by non-conventional sources is less than their counterparts. Renewable sources do not have any detrimental effect on the environment. Solar-wind hybrid system is basically an integration of solar plant and a wind energy plant. It will help in providing the uninterrupted power supply. As during bad weather conditions the production can be shifted from one plant to other with the help of a microcontroller. 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. It helps in decreasing the dependence on one single source and makes the system more reliable. The hybrid system can be used for both industrial and domestic applications.*

Key Words: Solar Energy, Wind Energy, PV Cell, Renewable Energy, Hybrid Power System, Electricity.

1. INTRODUCTION

We require electricity for operating almost all the appliances we use in our day to day life. So it has become an indispensable part of our life. Now there are two ways to produce electricity first by using non-renewable sources of energy and second by renewable sources of energy. With increase in population and advancement of technology, consumption of electricity is also increasing exponentially. Simultaneously, we have to increase the production of electricity also in order to meet the demands of growing population. The biggest disadvantage with the usage of conventional resources is that their usage causes pollution due to the production of various pollutants like ash in case of a coal power plant, smoke in case of diesel power plant, radioactive material in case of nuclear power plant. Maintaining these pollutants is not an easy task and it also requires a lot of money. So we have to find some other methods to produce electricity. The best possible way is by using non-conventional sources of energy. Out of all the possible options available in non-conventional sources of energy, solar and wind are the best methods. As tidal energy can be used only on the sea shores, ocean thermal energy can used in the middle of the sea and its setup is also very difficult. While solar and wind are available in all the areas of the world and setting up their power plant is also not a cumbersome task. The availability of solar energy is a major concern, as it is available for around 8 hours in a day, on the other hand wind is available almost for 24 hours. But we can do one thing to make up for that problem by integrating these two together. During foul weather conditions one of them can be used while during normal weather both can be operated together. So in this paper we will be describing a solar-wind hybrid power system.

1.1 Solar Energy

Solar energy is that energy which we get from the sun in form of radiation. It does not cause any kind of pollution, it is inexhaustible. It is available free of cost. Specially, in a country like India where sun shines for almost 300 days in a year, it is therefore a convenient mode of electricity production. Meager amount of investment is involved in setting up a solar power plant and also it is quite easy to maintain. The efficiency of the system is also quite good. Long life span and less emission of pollutants are its major advantages.

1.2 Wind Energy

When air flows then it is having some kinetic energy with it which is known as wind energy. This kinetic energy is converted into mechanical energy by the wind turbine, which is used to rotate the shaft of the generator and then electricity is produced. The cost of generation of electricity is quite less. The initial investment of the system varies depending on the type of turbine used. The best part about producing electricity with the help of wind energy is that wind is available for almost 24 hours in day, so there will not be any discontinuous production of electricity. The output varies with the speed of the wind.

1.3 Hybrid Systems

Now we have become even more interested in usage of renewable energy sources as an alternative method of producing electricity. Hybrid systems are basically an integration of solar panels and wind turbine, the output of this combination is used to charge batteries, this stored energy can then be transmitted to local power stations. In this system wind turbine can be used to produce electricity when wind is available and solar energy panels are used when solar radiations are available. Power can be generated by both the sections at the same time also. The usage of batteries is to

provide uninterrupted power supply. This system requires high initial investment. But the reliability, long-life span and less maintenance make up for that disadvantage. The power output of the wind turbine is AC which is converted to DC with the help of a rectifier. 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.

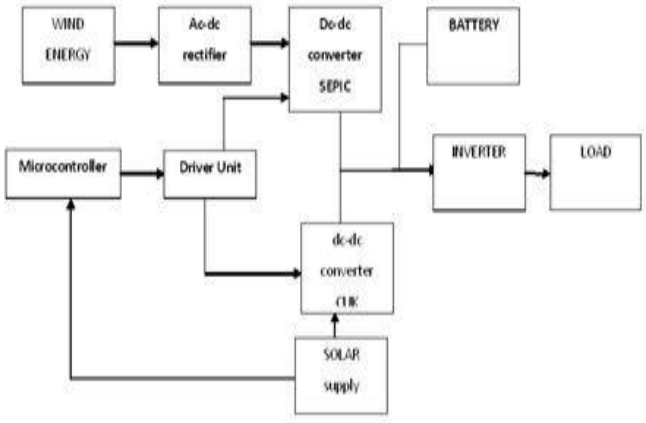

Fig-1: Block Diagram a hybrid system

2. COMPONENTS USED:

2.1 Solar Panels

A solar cell is used to convert solar energy into electric energy, it is also known as photovoltaic cell. It is a p-n junction diode which consist of two different layers of a semi-conductor material called as n and p region, n region is heavily doped and is thin while p region is lightly doped and is thick. The radiation falling on the surface of p-n junction diode can pass through the n side. Most of the depletion region is contained in the p region which is lightly doped. The extent to which the n region can be penetrated is decided by the wavelength of the falling radiation. Electron–hole pairs are generated in the n and p region, due to the difference in potential the electrons move to the n region and holes towards the p region. The current starts flowing when an external load is connected to the terminals of the n and p regions. To make a solar panel multiple solar cells are connected in series and parallel combinations, they are connected in such a way that the output obtained is additive in nature.

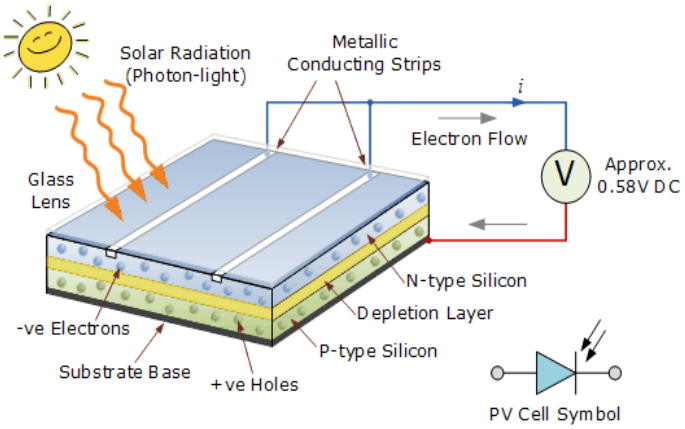

FIG-2: SOLAR CELL

2.2 Wind Turbine

Wind is a renewable source of energy. A wind turbine is used to convert the kinetic energy of the wind into electric. The generator connected to the shaft of the blades converts the mechanical energy to electric energy. The wind turbine is of two types depending upon the rotating axis of the blades, first is vertical axis wind turbine and horizontal axis wind turbine. The output of the turbine depends on the speed of the wind. The power generated by the turbine is fluctuating. In order to obtain continuous supply of power first the electricity is stored in a battery unit and then it is transferred to the load.

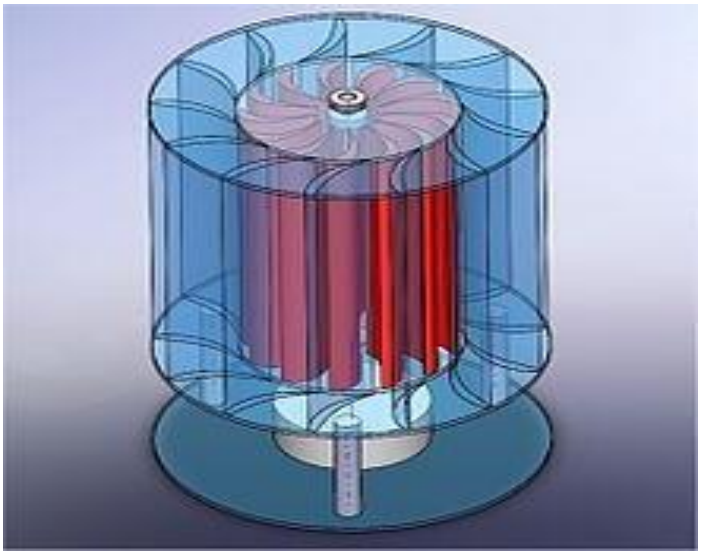

Fig 3:- Vertical Axis Wind Turbine

2.3 Batteries

The batteries are used in order to store the electricity that is produced from wind and solar energy. The capacity of battery may vary depending on the size of wind turbine or solar power plant. Battery should be having low maintenance and charge leakage should also be low. Considering all these parameters free discharge type is the best option available. Multiple batteries can be connected in series and parallel to

increase or decrease the capacity of the battery, depending upon the output from the hybrid systems.

2.4 Inverter

As we know that most of the electrical appliances require AC voltage, so first the DC output of the batteries will be converted into AC voltage with the help of an inverter and then it will be transferred to the loads. The inverter must be having over voltage protection, reverse polarity and short circuit protection.

2.5 Microcontroller

The function of microcontroller is to compare the input of the both the power systems and then it operates the relay used, in order to charge the batteries. The DC voltage used in the batteries is converted to AC with the help of an inverter. To the secondary winding of the center tapped transformer used a MOSFET is connected. 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.

3. Hybrid Energy Systems

3.1 Block Diagram

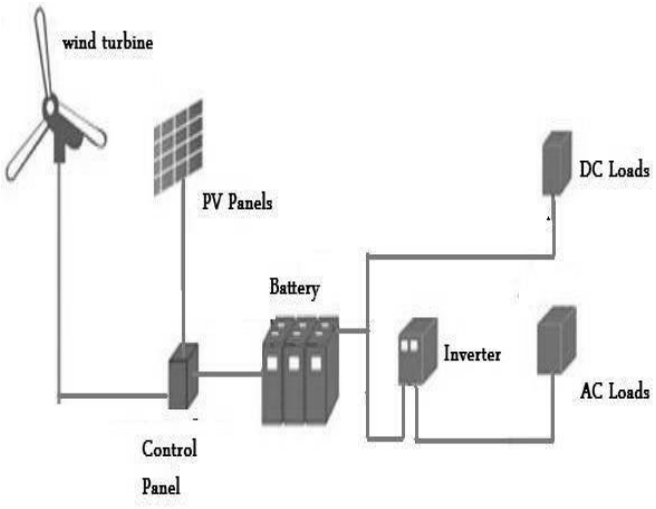

Fig -4: Hybrid Systems

Now the required amount of electricity can be produced depending on the environmental conditions, by using two systems at the same time or by using only one, according to the conditions pertaining at that point of time.

4. Proposed Calculations

Overall power generated by system is the summation of the power generated by the solar PV panel and power generated by the wind turbine. Mathematically, it can be represented as,

$$PT = NW * Pw + Ns * PS$$

Where,
Total power generated= P_T
Power generated by wind turbines= P_W
Power generated by solar panels= P_S
No. of wind turbine = N_W
No of solar panels used= N_W

A. Calculations for wind energy:

The power generated by wind energy is given by,
Power = (density of air * swept area * velocity cubed)/2

$$P_W = ½. \rho (A_W) (V)^3$$

Where,
P is power in watts (W)
ρ is the air density in kilograms per cubic meter (kg/m^3)
A_W is the swept area by air in square meters (m^2) V is the wind speed in meters per second (m/s).

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

$$P_S = Ins\ (t) * A_S * Eff(pv)$$

Where,
Ins (t) = isolation at time t (kw/ m^2)
A_S = area of single PV panel (m^2)
Effpv = overall efficiency of the PV panels and dc/dc converters.
Overall efficiency is given by,

$$Eff(pv) = H * PR$$

Where,
H = Annual average solar radiation on tilted panels.
PR = Performance ratio, coefficient for losses.

C. Cost

The total cost of the solar-wind hybrid energy system is depend upon the total no of wind turbines used and total no of solar panels used. Therefore the total cost is given as follows

Total cost= (No. of Wind Turbine * Cost of single Wind Turbine) + (No. of Solar Panels * Cost of single Solar Panel) + (No. of Batteries used in Battery Bank * Cost of single Battery)

$$C_T = (N_W * C_{WT}) + (N_S * C_{SP}) + (N_B * C_B)$$

Where,
C_T is the total cost in Rs
C_{WT} is the cost of single wind turbine
C_{SP} is the cost of single solar panel in Rs
C_B is the Cost of single Battery in Rs
N_W is the number of wind turbine used
N_S is the number of solar panels used
N_B is the number of Batteries used in Battery Bank.

5. EXPERIMENTAL SETUP

Fig-5: Experimental Setup

This is the model of solar-wind hybrid system, the power developed by the system is transferred to the load as shown in the figure. The output voltage and current of solar panel, wind turbine, batteries and load are measured very precisely and then the final results are calculated. Amount of power produced and consumed are measured.

Solar-PV Wind hybrid power specifications are given below.

PV Array Power = 20 watts
Wind turbine/generator = 3 W
System Voltage = 48V
Battery=12V
Inverter Rating (VA) 25
Output AC Wave form Sine-wave
Output AC Voltage (Vnom), +/-10% = 230 V/AC Output Ac Frequency, Hertz, +/-0.5 % = 50 Hz.

6. CONCLUSIONS

Developing hybrid systems is one of the most convenient and effective solution for producing electricity as compared to non-renewable energy resources. It is not only less costly but also it does not cause any harm to the environment. Another thing is that it can be used to generate electricity in hilly areas, where it is quite difficult to transmit electricity by conventional methods. Depending on the requirement its setup can be decided. All the people in this world should be motivated to use non-conventional resources to produce electricity in order to make them self-reliable to some extent. Long life span, less maintainence are some of its plus point. It just requires some high initial investment.

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