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Hybrid Power Generation Model using Wind Energy and Solar Energy

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***Abstract*—One of the basic needs for development of any nation in the world is to provide reliable and steady supply of electricity. Now-a-days the electrical energy is considered to be the driving force for social and economic development of a nation. To cope with the growing demand of electricity, it is become a necessity to generate power from different renewable energy resources. In context of this, generation of electricity using sustainable energy resources can be more productive. This paper describes a hybrid Electrical Power Generation model by integrating photovoltaic Solar Energy and Wind Energy without disturbing the ecological balance. Basically we can achieve uninterrupted power by using this hybrid energy system. Moreover this process reduces the generation cost to a minimum value. The equipment consists of combination of PV solar-cell, a mast mounted wind generator, storage batteries and an inverter used to convert DC power to AC power throughout the system. This hybrid solar-wind power generating system is suitable for both Industries and domestic utilization**

***Keywords*- Hybrid Power Model, PV Cell, Renewable Energy, Solar Energy, Solar-Wind Model, Wind Energy.**

I. INTRODUCTION

Electrical Energy is playing an important role in human and economic development. The driving forces for social and economic development and a basic demand of nation is electrical energy. In parallel to developing technology, demand for more energy makes us seek new energy sources. In parallel to developing technology, demand for more energy makes us seek new energy sources. Researches for renewable energies have been initiated first for solar power and then for. wind power . Efficiency of solar power conversion systems is ca. 18%, whilst that of wind power is ca. 55%. These efficiencies could be increased by 50% with beam tracking, beam focusing and wind direction adaptive motion methods[1][2].

Renewable energy is clean, affordable, domestic, and effectively infinite. It produces no emissions and results in cleaner air and water for all. Wind energy is now one of the most cost-effective sources of new generation, competing with new installations of coal, gas and nuclear power. Solar power can also help meet global energy demand The United States has some of the best wind resources in the world, with enough potential energy to produce nearly 10 times the country's existing power needs[3].

Nowadays Solar installations exceed 3,100 megawatts, enough to power more than 630,000 homes. The solar industry employs more than 100, 000 Americans and grew by 69 percent in 2010, making it one of the fastest growing sectors in the U.S. The price of solar panels has dropped by 30 percent since 2010 and costs continue to fall. The United States was a net exporter of solar products in 2010 by $2 billion. In India, the total installed capacity touched the figure of 33,791 MW with wind power contributing 22,465 MW, Solar 3,062 MW [4][5].

Wind and solar hybrid model with proper storage system have been keen interest for the last few years. Hybrid energy are reliable sources of electricity that can diversify our nation's energy portfolio. This Paper focuses on the combination of solar wind systems for sustainable power generation. The solar energy varies with the hourly, daily and seasonal variation of solar irradiation. The wind turbine output power varies with the wind speed at different conditions. It shows the capacity and potential for solar-wind hybrid electricity-generating system installed in our country. The designing of this system is done in such a way that it is very compact and acts as user friendly. When it is manufactured in a large scale, cost of this integrated natural resources power generation system is affordable. Moreover there is no power failure or load shedding situation at any times as there is a inter connection with the grid system. Therefore, it is the most reliable power or electricity resources having less expenditure.

II. ENERGY RESOURCES

A. Electrical Energy Generation

a) Conventional Methods:

1) Thermal- Thermal energy used for producing steam for turbines which drive the alternators.

2) Hydroelectric-Potential of water stored at higher altitudes is utilized as it is passed through water turbines which drive the alternators.

b) Non-Conventional Methods-

1) *Wind Power*- High velocities of wind are utilized in driving wind turbines coupled to alternators. Wind power has a advantage of zero production cost. The cost of the equipment and the limit of generating unit rating is suitable for a particular location are the important constraints. The method has exclusive advantages of being pollution free and renewable.

2) *Solar Cell/Photo Voltaic Cell*- These directly convert solar energy into electrical energy through a chemical action taking place in solar cells. These operate based on the photo voltaic effect which develops an emf on absorption of ionizing radiation from sun.

3) *Fuel cell*- These are devices which enables direct conversion of energy chemically into electrical form. This is an upcoming technology with a special merit of being pollution free.

4) *Nuclear Energy*- Towards the end of Second World War, it was discovered that large amount of heat energy is liberated by the fusion of uranium and other fissionable materials. It is estimated that heat produced by 1kg nuclear fuel is equal to that produced by 4500tonnes of coal. There are some difficulties in the use of nuclear energy. The principals are

a) high cost of nuclear plant, b) problem of disposal of radioactive waste and dearth of trained personnel to handle the plant.

B. Type of Load

A device with taps electrical energy from the electric power system is called a load on the system. The various types of load on the power system are-

a) Domestic Load- Domestic load consist of lights, fans, televisions, small motors, for pumping water etc. most of the residential loads occurs only for some hours during the day (i.e.24 hours a day).

b) Commercial Load- Commercial load consist of lighting, for shops, fans, and electric appliances used in restaurants etc. this class of load for more hours during the day as compared to the domestic load. The commercial load has seasonal variation due to the extensive use of air conditioners and space heaters.

c) Industrial Load- Industrial load consists of load demand by industries. The magnitude of industrial load depends upon the type of industry. Thus small scale industry requires load up to 25kW, medium scale Industry between 25kW and 100kW and large scale industry requires load above 500kW.

d) Municipal Load- Municipal load consists of street lighting, power required for water supply, drainage purposes. Steer lighting load is practically constant throughout the hours of the night.

e) Irrigation Load- The type of load is the electric power needed for pumps driven by the motors to the supply water to fields.

f) Traction Load- This type of load includes trams, cars, buses, railways etc. tis class of load has wide variation. During the morning hours, it reaches peak value because people have to go there work place. After morning hours, the loads start decreasing and again rises during evening since the people start coming to the homes.

C. Wind Power Generation

To extract energy from wind and to convert that energy into electrical power, we need a Wind Turbine setup which can convert the mechanical power into electrical power. The blades of the wind turbine are fixed to the rotor part of the generator set which is mounted on the turbine using gear-arrangement.

Wind with a speed of 5km/hr or more causes the rotation of the blades of the turbine. As the blades rotate, the mechanical power then converts into electrical power with the help of generator set.

The amount of energy which the wind transfers to the rotor depends on the density of the air, the rotor area, and the wind speed. Block diagram representation of Wind power generation is shown in the Fig 1.

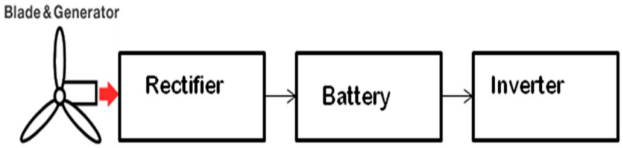

Fig 1. Block diagram representation of Wind power generation

D. Solar Power Generation

Sun gives us energy in terms of both heat & light. But we are using light energy for producing electrical energy. The system which converts sunlight to electrical energy is called Solar Cell. It is basically a photo-voltaic cell or PV cell which is photo sensitive[6][7][8].

When sunlight falls on the N side, the free electrons flows from N to P. As the electron get enough energy to breakdown the bond and flow through the load. So current flows in opposite direction. This is the main operating principle of solar cell. Block diagram representation of Wind power generation is shown in the Fig 2.

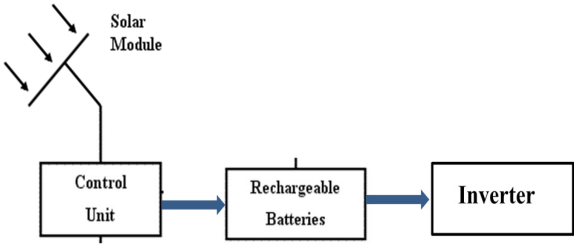

Fig 2. Block diagram representation of Solar power generation

The equivalent circuit of solar cell is given in Fig 3.

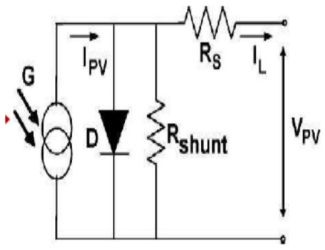

Fig 3. Circuit diagram representation of Solar cell

The PV cell is arranging in Fig 4.

Fig 4. Representation of PV Cell

III. WIND SOLAR HYBRID POWER SYSTEM MODEL

After successful power generation from both the power source, we will combine the two power source.

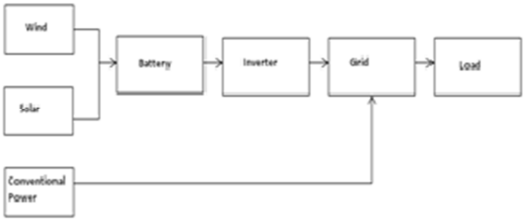

Fig 5. Block diagram representation of Hybrid Power System model.

A. Inverter

An inverter is an electronic device or circuitry that changes direct current (DC) to alternating current (AC). The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. A typical power inverter device or circuit requires a relatively stable **DC power source** capable of supplying enough current for the intended power demands of the system. The input voltage depends on the design and purpose of the inverter, e.g., 12VDC, for smaller consumer and commercial inverters that typically run from a rechargeable 12V lead acid

battery[9][10].

B. Circuit Diagram

The necessary circuit diagram of inverter is shown in Fig 6.

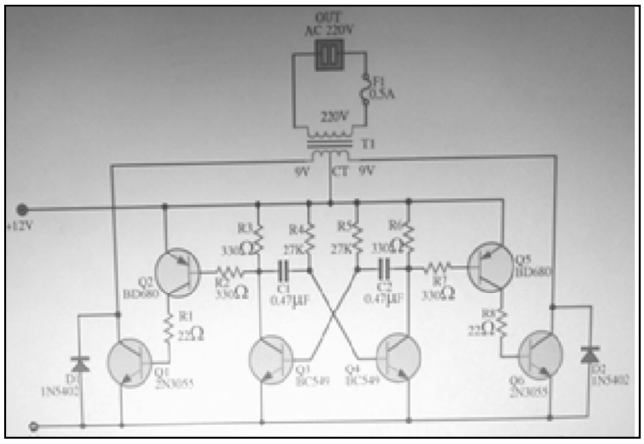

Fig 6. Circuit diagram of Inverter

C. Output Waveform and Frequency

An inverter can produce a square wave, modified sine wave, pulsed sine wave, pulse width modulated wave (PWM) or sine wave depending on circuit design. The two dominant commercialized waveform types of inverters as of 2007 are modified sine wave and sine wave.

There are two basic designs for producing household plug-in voltage from a lower-voltage DC source, the first of which uses a switching boost converter to produce a higher-voltage DC and then converts to AC. The second method converts DC to AC at battery level and uses a line-frequency transformer to create the output voltage. The output waveform of inverter is given in the Fig 7.

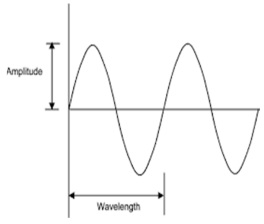

Fig 7. Output waveform of Inverter

The AC output frequency of a power inverter device is usually the same as standard power line frequency, 50 or 60 Hz. The AC output voltage of a power inverter device is often the same as the standard power line voltage, such as household 120 VAC or 240 VAC allows the inverter to power numerous types of equipment designed to operate off the standard line power.

IV. MODELLING OF HYBRID POWER SYSTEM

A. *Proposed Block Diagram of Hybrid Power system.*

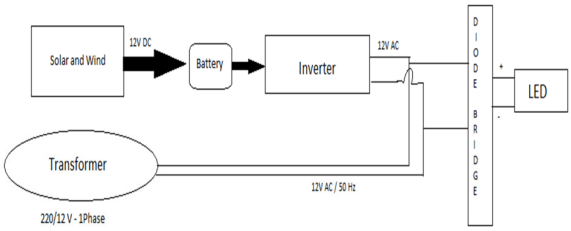

Fig 8. Proposed Block diagram of Hybrid Power System.

B. *Proposed Mathematical Calculation*

a. Calculations for solar energy:

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

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

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

Overall efficiency is given by, $\eta(pv) = H * P_R$
Where, H = Annual average solar radiation on tilted panels.
P_R = Performance ratio, coefficient for losses[12].

b. 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/m³)
A_W is the swept area by air in square meters (m²)
V is the wind speed in meters per second (m/s).

c. Calculations for Total Power:

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[13][14]. Mathematically it can be represented as,

$P_T = N_W * Pw + Ns * P_S$

Where, P_T 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
Ns is the no of solar panels used in the system

V. RESULTS

The model of hybrid grid system has been designed by connecting the Solar and Wind turbine system along with the conventional energy sources. This combined circuit fed power to the battery bank which in turn charges the inverter circuit. The output of this hybrid model is depends on availability of solar irradiance and flow of wind. The stand-alone wind system is suitable not only for seasonal changes but also for different application. The shortfall of the required output energy will compensate by the Battery bank in the peak demand conditions. A model of the proposed system was designed, implemented and simulated by using a suitable load circuit. The output results that obtained are shown below:

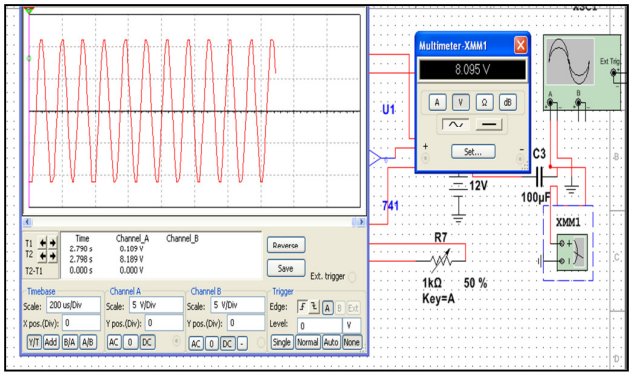

Fig 9. Output waveform of Hybrid Power System model

- The input voltage given: 12 V DC.
- The output waveform: Sinusoidal Curve.
- The output frequency: 50 Hertz.
- The output voltage obtained: 10.5 V AC

VI. CONCLUSION

Hybrid power generation model using solar and wind energy is very effective solution for power generation than conventional energy resources. Its efficiency is always better. It can use in remote areas where government is unable to reach. So that the power can be utilize where it

generated so that it will reduce the transmission losses and cost. Although initial cost for solar-wind hybrid power system is high, but it produces electricity at least cost. Due to distributed generation it eliminates installation cost transmission lines. It has many advantages that it produces no pollution and requires less maintenance. People should motivate to use the non conventional energy resources. It is highly safe for the environment as it doesn't produce any emission and harmful waste product like conventional energy resources. An initial investment is required for that purpose. So it is reliable for electricity generation.

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