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Modelling of Hybrid Solar/Wind Energy System for Rural, Remote and Hilly Areas in Rajasthan (India)

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***Abstract*—**This paper presents the design and analysis of a hybrid Solar and Wind System for rural electrification in a remote area in Rajasthan. It is need to provide electricity for household use to each family in each locality including remote areas of each state. Energy is crucial input in the process of economic, social and industrial development. Energy plays a vital role in our daily life. But the conventional source of energy to produce electricity is decreasing day by day significantly. In this regards nonconventional or renewable energy resources such as bio-energy, Solar, Wind, Ocean and Geothermal are taking this challenge. A large proportion of the world's population lives in remote rural areas and far away from grid. The installation and distribution costs are considerably higher for remote areas. Moreover, there is greater transmission line losses and poor supply reliability. The combining of technologies means Hybrid technology provides interesting opportunities to overcome certain technical limitations and to mitigate fuel price increases, deliver operating cost reductions, and offer higher service quality than traditional single-source generation systems. A hybrid system is a dynamic system that exhibits both continuous and discrete dynamic behaviour a system that can both flow and jump.

Index Terms* —Solar Power, Wind Power, Green Energy, Hybrid Solar and Wind System, Remote areas*

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I INTRODUCTION

Due to the critical condition of industrial fuels which include oil, gas and others, the development of renewable energy sources is continuously improving. This is the reason why renewable energy sources have become more important these days. Few other reasons include advantages like abundant availability in nature, eco-friendly and recyclable. Many renewable energy sources like solar, wind, hydro and tidal are there. Among these renewable sources solar and wind energy are the world's fastest growing energy resources. With no emission of pollutants, energy conversion is done through wind and PV cells At present obtaining reliable and cost effective power solutions for the household use specially for minimum needs like house light, for recharging mobile, for TV use in rural and remote areas is a very challenging problem. In such area Grids are either not available or their extensions can be extremely costly. A sustainable alternative to make availability of electricity at such area is to use renewable energy sources. Recent research and development of Renewable energy sources have shown excellent potential as a form of contribution to conventional power generation system. For Indian remote location one of the most alternative solutions of renewable energy sources is wind – solar hybrid energy system. It is use-full for house light and other domestic use like recharging mobile and to provide power for TV use in trible belt. Wind – Solar HybridelectricityofferpowerSupplysolutionforremotetribal areas, not accessible by the grid supply. [1]

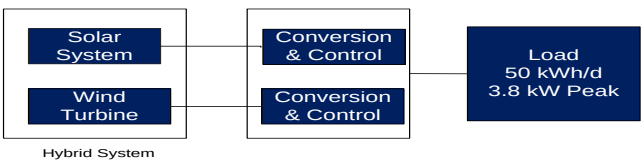

Figure 1 Block Diagram of Hybrid Power System

Day by day, the demand for electricity is rapidly increasing. But the available base load plants are not able to supply electricity as per demand. So these energy sources can be used to bridge the gap between supply and demand during peak loads. This kind of small scale stand-alone power generating systems can used in remote areas where conventional power generation is costly.a wind-photovoltaic hybrid power generation system model is studied and simulated. The selected hybrid energy system with 100% renewable energy contribution minimise the need for conventional source of power generation. The Rajasthan coordinate Latitude: 27° 00' N Longitude: 74° 00' E and geographical data of Rajasthan shown in figure.

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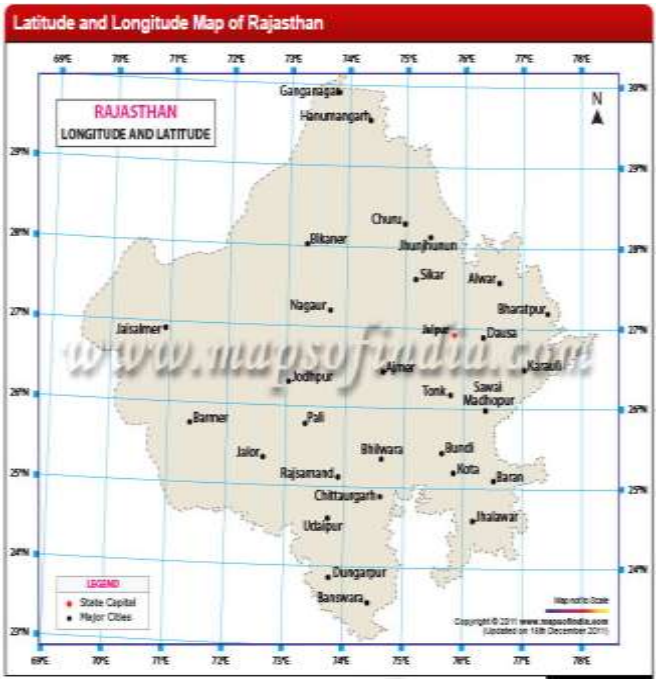

Figure 2 Geographical of Rajasthan

Figure 3TharDasart of Rajasthan

A. Wind/ Solar data & operational strategy of system

The hourly, monthly and yearly variations of wind speed at Rajasthan have been the matter of earlier studies. It has been noticed that wind speeds are generally higher in summer months(April to August) as compare to other months but the average flow of wind in south-west Rajasthan is maximum as compare to other areas in Rajasthan an around march to November continues the average wind flow so many companies as suzilon wind power are installed the wind power plant in Jaisalmer district. The data represented in the references also exhibits that there is a considerable variation of monthly average wind speed of the same month from one year to another. These variations show how the monthly energy output from wind would be subjected to considerable difference. The wind energy calculations are made by matching the power wind speed characteristics of commercial wind machines with the long term hourly wind speed data. [2]

II WIND ENERGY

Table I
AVERAGE ENVIRONMENTAL DATA OF RAJASTHAN (INDIA)

Month	Wind Speed (km/hr)	Solar Radiations ($kwh/m^2/d$)
Jan	3.05	4220.00
Fab	3.40	5210.00
March	3.41	6320.00
April	4.03	7060.00
May	4.61	7430.00
June	4.94	6720.00
July	4.25	6200.00
Aug	3.54	5740.00
Sep	3.41	6020.00
Oct	2.76	5570.00
Nov	2.68	4620.00
Dec	2.85	3990.00

$$P = \frac{1}{2}\rho A V^3 \quad (1)$$

Where, ρ =Air Density (1.225 kg/m3 at sea level)
A=Rotor Swept Area m^2
V= Speed (m/s)
The power 'P' yields in a free flow steam of wind. It is impossible to extract all the power from the wind turbine because some flow must be maintained through the rotor. [3] So, we need to include some additional terms to get practical equation for wind turbine.

$$P = \frac{1}{2}\rho A C_P V^3 N_g N_b \quad (2)$$

where, Cp = Coefficient of performance (0.59 Betz limited Maximum possible theoretical, 0.35 for a good design) N_g = Generator efficiency (80% or more for permanent Magnet machine) N_b = Gear box and bearing efficiency (95% around) For an AIR 403 Wind Electric Generator (400 watts)

$$P = \frac{1}{2}\rho A C_P V^3 \text{ watts} \quad (3)$$

Substituting the values for wind velocity as 12.5 m/s, radius 1.15m, ρ = 1.225. Substituting these values in the above equation we will get the value of Cp Therefore, Cp = 0.32
Tip speed ratio (λ) = Blade tip speed / wind speed

$$= r\omega/v \quad (4)$$

Where, r = radius of rotor in meters
ω = rotational speed in rpm
v = wind speed Substituting the values in the equation
λ=1.53

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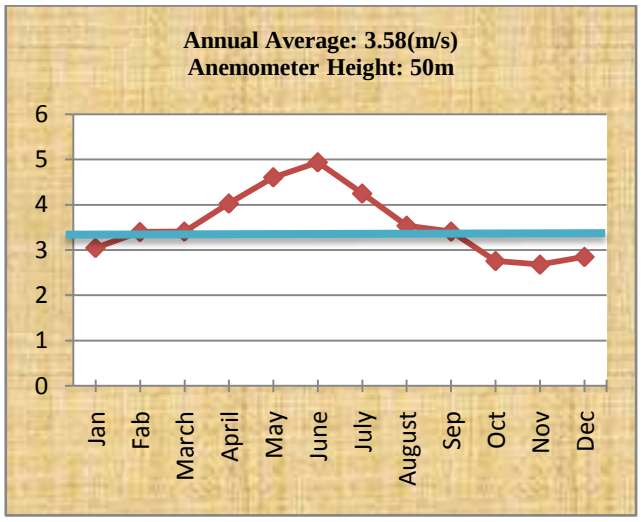


Figure 4 Wind Speed (km/hr) in Rajasthan, India

III SOLAR ENERGY RESOURCE

Hourly solar radiation data for the year was collected from environment of Rajasthan. Scaling was done on these data to consider the long-term average annual resource. According to solar radiation, Average daily radiations are available throughout the year is shown in figure 4. In summer solar power is higher than winter season and in rainy season clearness index and solar power availability is lower than summer and winter season. [4]

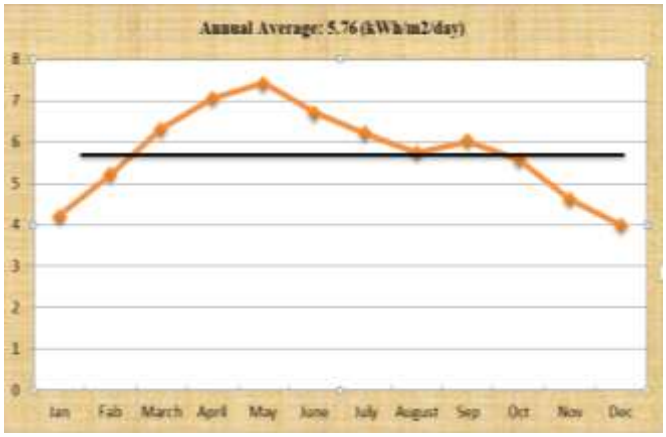


Figure 5 Solar Radiation (kwh/m^2/d) in Rajasthan India

IV HYBRID POWER SYSTEM

In India the power crisis increases rapidly, solar and wind or renewable energy sources plays important role to solve power crisis problem. Although the net present cost is high but the running and maintenance cost are low as compared to the Grid power solution. Its payback time is around 15 years. The Grid installation, Transmission and Distribution cost are also reducing to approximate 50%.with increasing equipment prices, payback times on the investment to hybrid solar-wind powered base station sites are continuously decreasing. Considering operating cost and maintenance cost, an autonomous site powered by wind solar hybrid system pay-off after 2-4 years in a good sunny and windy location. The Base stations powered by the solar wind hybrid energy system with diesel backup – are proving to be the most environmentally friendlyandcosteffectivesolutionsformanychallenging sites. Operating and maintenance costs are extremely low, making it economical to extend cellular coverage in far-flung regions. Solar- and wind-powered sites benefit the environment as well as the operator business case, whether they are located in highly populated, remote areasand hilly areas. Due to powering the base station by hybrid renewable energy system, it will reduce the carbon and other harmful gases emission is about 90% in environments. [5][6]

V SIMULATION RESULTS OF HYBRID POWER SYSTEM

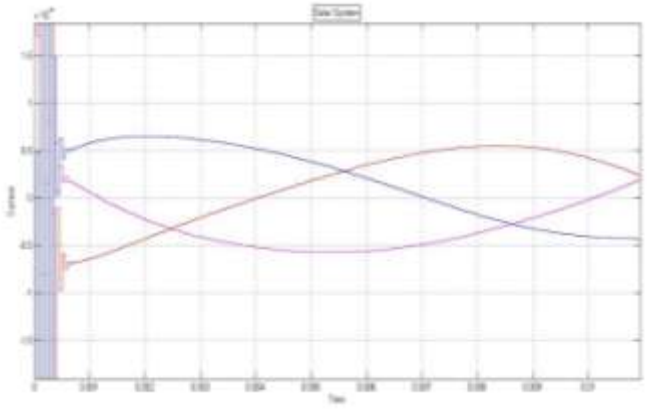
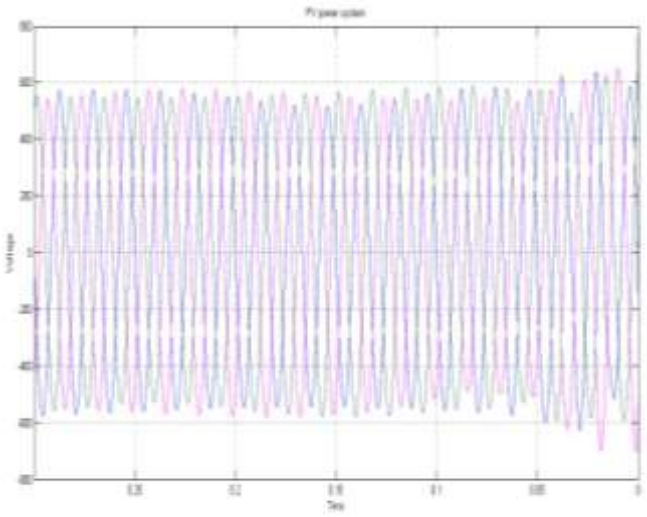


Figure 6 Solar System Output Current



Fugure 7 Solar System Output Voltage

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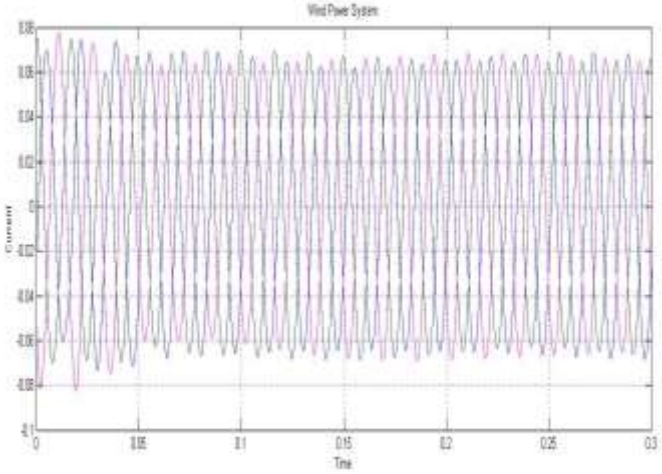

Figure 8 Wind Turbine Output Cureent

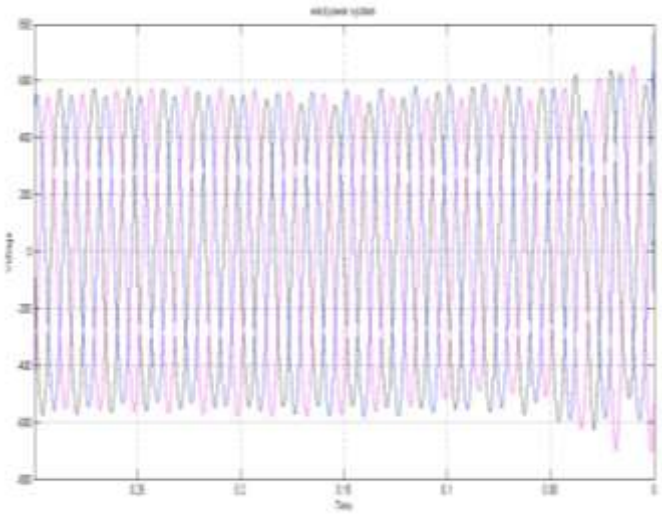

Figure 9 Wind Turbine Output Voltages

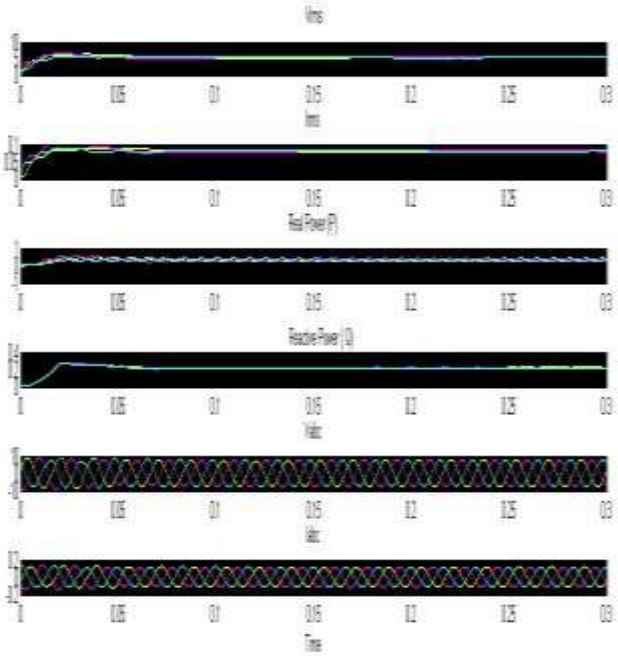

Figure 10 Hybrid System Output

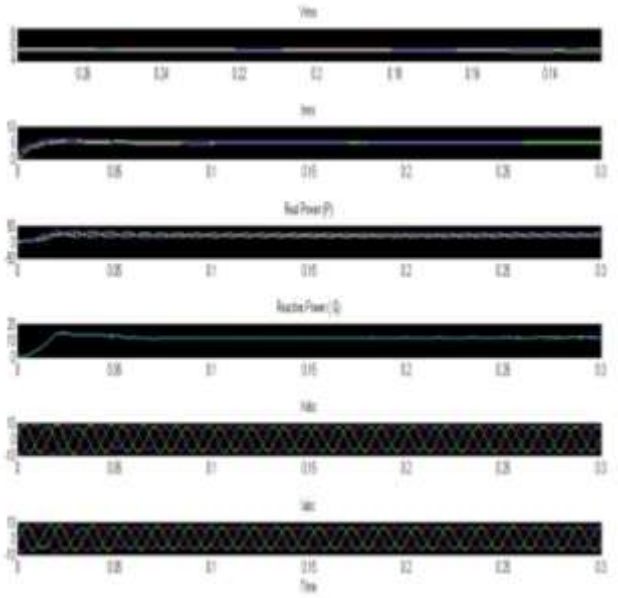

Figure 11 Hybrid System Output Load Side

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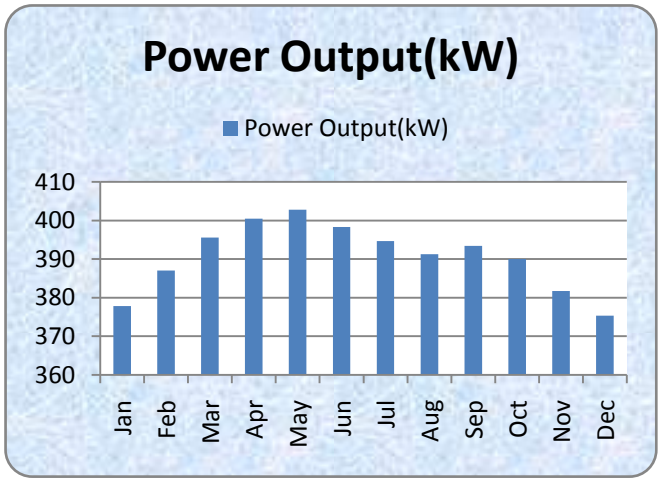

Figure 12 Hybrid Power Output throughout the Year

VI CONCLUSION

To provide better power supply services four household the mini hybrid wind - solar power plant is use-full and in this paperwehavestudiedtheoffgridelectrificationthroughhybrid power. Power is main issue for remote or isolated areas base station, because grid extension is not feasible. In these sites the above proposed renewable base hybrid system is most viable solution. These solutions of power supply to the households are cost effective and available throughout the year. The circumstance of each sites are studied in order to decide the feasible combination of alternative energy resources. Alternate power solutions are not commonly used in household system today but are actively evaluated for remote and isolated areas over worldwide. With the help of above pre-feasibility study the solar and wind hybrid energy systemare most viable power solution for trible belt in Indian sites over conventional grid supply system.

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