Rural Electrification by Effective Mini Hybrid PV Solar, Wind & Biogas Energy System for Rural and Remote Areas of Uttar Pradesh

Mohibullah, Sagar Bhardwaj, and Shashank K Garg

***Abstract*—**The most essential need of human beings is electricity from household to industrial work. In this modern era, it is the need of each family in remote and rural areas. This paper presents an analysis of power supply using abundant solar, wind and biogas as a hybrid energy in west of Uttar Pradesh. These areas include nearbyrural parts of Harduaganj, Aligarh, Hathras, Sasni, Saatha, Baraithi. These are the flat areas of Uttar Pradesh where population density is 200 persons per square kilometre. Geographically it is flat plateau area where due to scattered huts it is very costly to supply electricity. Solar, wind, biogas energy present in abundance can be made to sustainable use and a reliable hybrid system can be designed. To enlighten these huts in dark nights and to provide them electricity for household hybrid wind- solar energy- biogas may be boon for this area.

***Keywords*—** Green Energy, remote and rural areas, solar energy, wind power, wind-solar-biogas hybrid power.

I. INTRODUCTION

THE present scenario of obtaining reliable and cost effective power solutions for the household use especially for minimum needs like house light, for recharging mobile, for TV use in rural and remote areas is a very challenging problem. In such areas grids are either not available or their extensions can be extremely costly. A cheap, sustainable alternative to make availability of electricity at such area is to use renewable energy sources. For such remote locations of Uttar Pradesh, the most alternative solution of renewable energy sources is PV Solar-Wind & Biogas hybrid system [1]. It is capable of producing light for household appliances. The main idea behind this is to make such villages self-sustaining. This paper focuses on the use of PV Solar and biogas mainly, because wind is not that abundant in these regions, and if used can be used only on a small scale, i.e. single house system. Biogas is a resource which is abundant in villages due to cattle and agriculture and thus is the most important resource for this system.

This paper discusses use of biogas for cooking and the possibility to generate enough steam to run a micro turbine system.

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TABLE I
GEOGRAPHICAL DATA OF WEST U.P.

Name of District	Longitude	Latitude
Aligarh	27.88E	78.11N
Hathras	27.60E	78.05N
Bulandshahar	28.40E	77.84N
Harduaganj	27.94E	78.15N
Sasni	27.70E	78.08N
Jawan	28.02E	78.11N
Mandrak	27.79E	78.08N

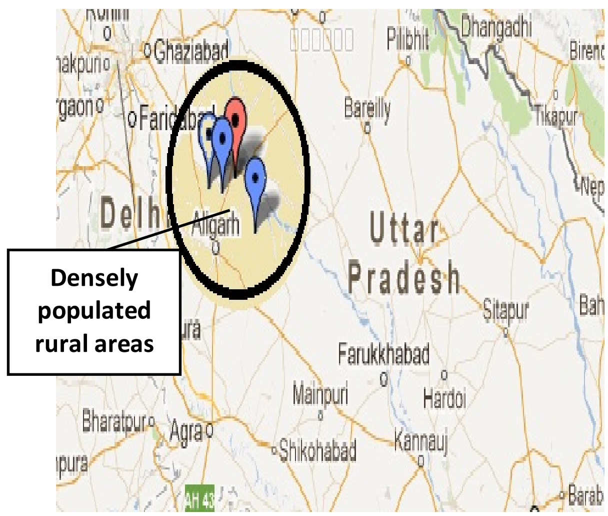

Fig. 1 Flat areas in Uttar Pradesh

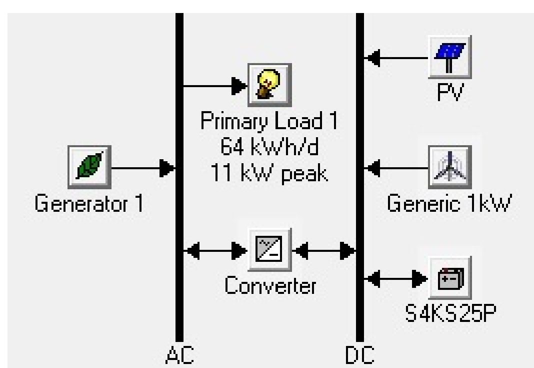

Fig. 2: Block Diagram of Hybrid Power System

II. WIND/SOLAR BIOGAS DATA & OPERATIONAL STRATEGY OF SYSTEM

The hourly, monthly and yearly variations of wind speed at west Uttar Pradesh 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 west Uttar Pradesh is maximum as compare to other areas in Uttar Pradesh and around March to November continues the average wind flow which is quite low. 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. The wind energy calculation are made by matching the power wind speed characteristics of commercial wind machines with the long term hourly wind speed data [2].
The data is calculated on an average taken by NASA Satellite data and Ministry of New and Renewable Energy, Government of India [3].

TABLE II
AVERAGE ENVIRONMENTAL DATA OF ALIGARH (U.P.)

Month	**Wind Speed (m/sec)**	**Solar Radiation ($kWh/m^2/day$)**	**Clearness Index**
Jan	1.800	725.000	80.20
Feb	2.100	780.000	79.457
Mar	2.200	800.000	92.540
Apr	2.400	830.000	49.263
May	2.700	875.000	86.598
Jun	3.000	880.000	72.196
Jul	3.200	860.000	76.861
Aug	2.800	700.000	96.524
Sep	2.300	825.000	80.62
Oct	1.900	830.000	74.33
Nov	1.700	780.000	78.95
Dec	1.650	740.000	85.23

A. Wind Power Equation

To collect wind energy, we are using wind turbines made up of D.C generators with mechanical model. The wind turbine is capable of rotating with small amount of wind pressure from the ambient. The maximum output of theturbine will be 24W. This can further be enhanced to a larger value for real time implementation [4]-[6]. The common cycle system wind turbine with a horizontal axis is simple in working principle and it will produce an electric power economically. The kinetic energy in the varying wind is converted into rotary mechanical energy by the wind turbine rotor.

$$P = \frac{1}{2}\rho A V^3 \tag{1}$$

Where, ñ =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. So, we need to include some additional terms to get practical equation for wind turbine.

$$P = \frac{1}{2}\rho A C_p V^3 N_g N_b \tag{2}$$

Where, C_p= 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)

$$P = A C_p V^3 \text{ Watts} \tag{3}$$

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

$$= r\,ù / v \tag{4}$$

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

ë = 1.53

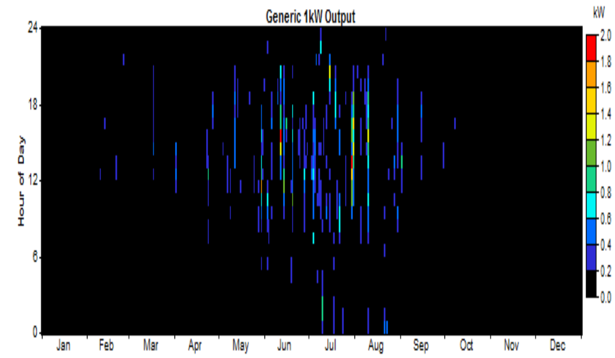

Fig. 3.Average Daily Wind Speed (km/hr) in Uttar Pradesh

B. Weibull Distribution

The measured wind speed variation for a typical site throughout a year indicates that the strong gale force winds are rare, while moderate and fresh winds are quite common, and this is applicable for most areas. Figure 4 shows the Weibull distribution describing the wind variation for a typical site. The Weibull probability density distribution function is given by

$$F_{(v)} = k \times \frac{V^{(k-1)}}{C^k} \times e^{-\left(\frac{v}{C}\right)^k} \tag{5}$$

K is the Weibull shape factor, it gives an indication about the variation of hourly average wind speed about the annual average, C is the Weibull scale factor [7]. Each site has its own K and C , both can be found if the average wind speed V and the available power in wind (flux) are calculated using the measured wind speed values. Graph shown in figure 4 gives a relation between the Weibull scale parameter C and average wind speed V as a function of shape parameter K.

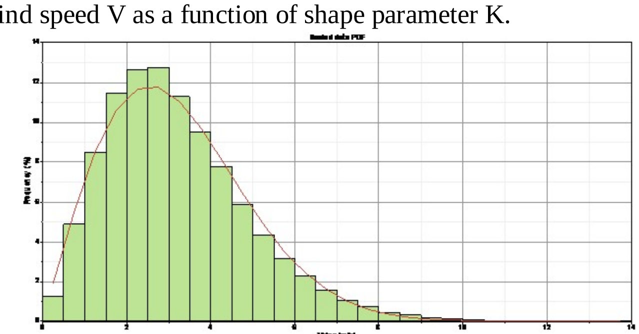

Fig. 4:Weibull scale parameter C and average wind speed V as a function of shape parameter K

Seeing the wind speed being very low in parts of Uttar Pradesh, here is the proposal of a new type of Wind turbine as shown below. This has normal rim of the tyre system to which the alternators are being attached for better performance and generate electricity. We can have at maximum of 6-8 for a small wind plant seeing the sustainable and feasibility of the plant as shown in Fig. 5

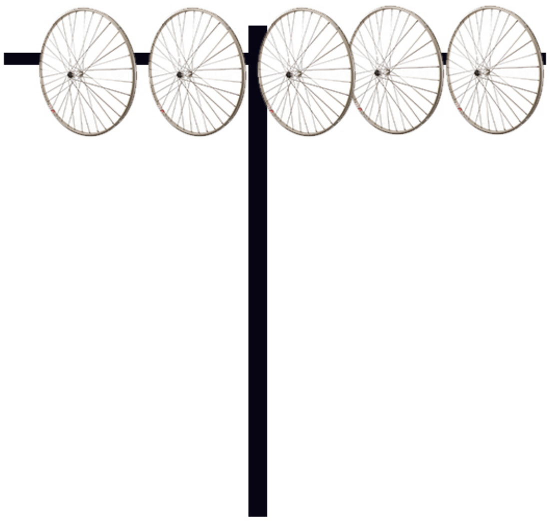

Fig.5: Wind Energy Model

III. Solar Energy Resource

Hourly solar radiation data for the year was collected from environment of Aligarh (Uttar Pradesh). Scaling was done on these data to consider the long-term average annual resource. The average wind speed solar radiation and clearness index data for the latitude is shown in table 2. According to solar radiation, Average daily radiation are available throughout the year is shown in figure 6. 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.

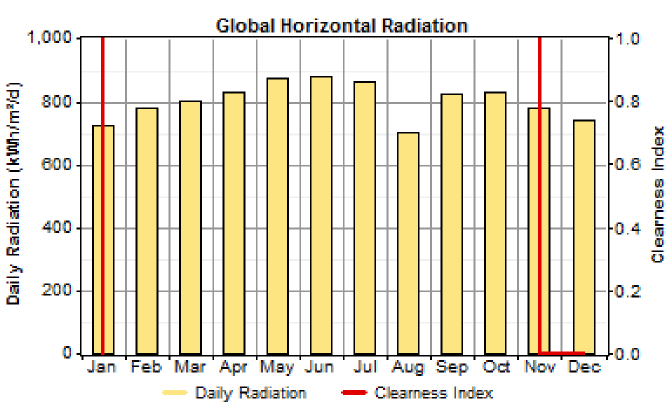

Fig. 6. Average Daily Radiation in a Year

IV. Biogas Plant

There are various biogas plants systems which can be incorporated in the hybrid model that are as follows:

1. Fixed Dome Type Biogas plant
2. Floating Drum type Biogas plant
3. Prefabricated Type Biogas Plant

There is huge supply of the dung in villages of Uttar Pradesh as per the survey of AFPRO's. The capacity installed is insufficient to meet the demands to a larger applications.

V. Hybrid Power System

In India the power crisis increases rapidly, solar, biogas 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. It's 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-biogas-wind powered base station sites are continuously decreasing. Considering operating cost and maintenance cost, an autonomous site powered by wind solar-biogas 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 friendly and cost effective solutions for many challenging 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 areas, tribal area and 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.

VI. Simulation Results Of Hybrid Power System

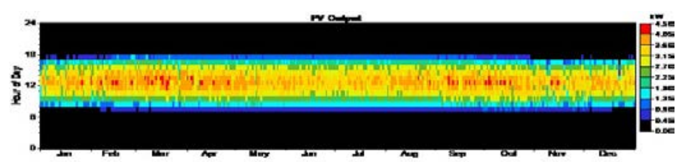

Fig. 7. PV- Output Power

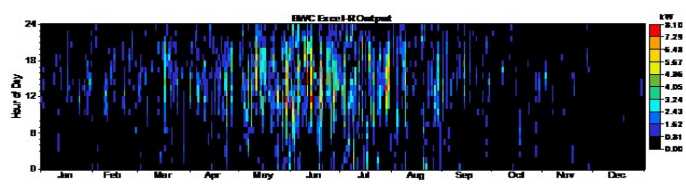

Fig. 8. Wind Turbine Output Power

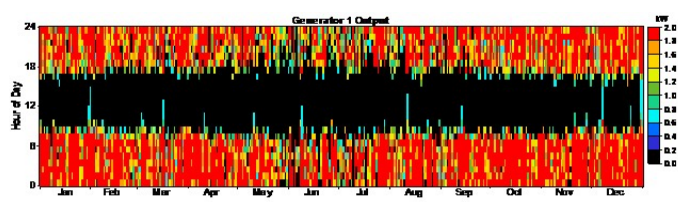

Fig. 9. Generator Output Power

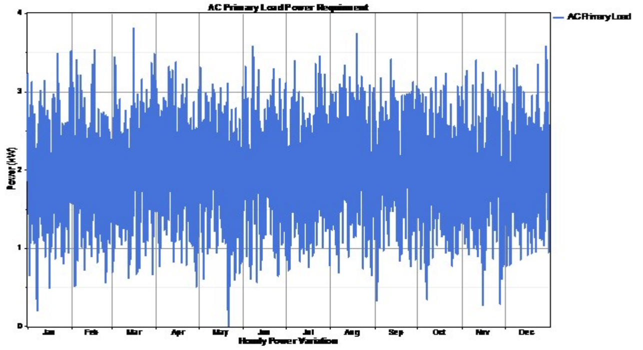

Fig. 10. AC Primary Load Power

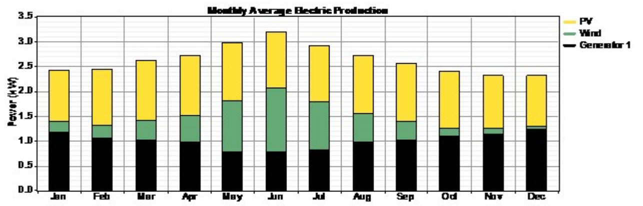

Fig. 11.Hybrid Power Output throughout the Year

All the results have been simulated with Homer Energy Simulations [8], which is monitored by NASA for accurate measurements

VII. System Architecture & Total Cost Analysis

In this simulation results eliminates all infeasible combinations and ranks the feasible systems according to increasing net present cost. It also allows a number of parameters to be displayed against the sensitivity variables for identifying an optimal system type. The Monthly Average Electricity Production of Hybrid Energy System for Electrification.

VIII. Conclusion

To provide better power supply services for household the mini hybrid wind - solar power plant is use-full and in this paper we have studied the off grid electrification through hybrid 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 of solar-biogas-wind hybrid energy system are most viable power solution for tribal belt in Indian sites over conventional grid supply system.

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