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HYBRID POWER MODEL OF RENEWABLE ENERGY SOURCES FOR ON GRID POWER SUPPLY

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ABSTRACT: This paper describes the process used to plan, design, and implement an on-grid electrical system for an institution located in rural area. The proper hybrid model of renewable energy will meet the power demand in remote areas where the grid supply is not reliable and efficient. Also the extra generated power can be supplied to grid for revenue generation. The rapid advances in wind-turbine generator, Biomass generator and photovoltaic technologies have brought opportunities for the utilization of these resources in remote areas gives a better alternative for grid power. The use of Biogas, wind and solar resources for electric power generation is available throughout the world free of cost. Hence, the economic aspects of these technologies are now adequately hopeful to also justify their use in small-scale stand-alone applications for small institutional use. If the development of a computer-based approach for evaluating the general performance of standalone hybrid wind-biogas-PV generating systems are analyzed and their results are reached to the common consumer with the economic analysis these systems can made our power supply system more efficient and reliable.

In this paper a simulation approach has been suggested for designing On-grid system. Hourly average of wind speed/solar radiation and biomass data is taken for the generating unit and the anticipated load data are used to predict the general performance of the generating system. The excess wind/biogas/solar-generated power, when available, is used to supply the power to the on-grid. Simulation studies were carried out using HOMER software. Simulation results will be given for performance evaluation and its efficiency of a stand-alone hybrid wind-Biogas-PV generating unit for a small institution assumed to be located in a remote area which is analyzed as connected with grid and without connected to grid. Finally, the results obtained and methods are suggested to enhance the performance of the proposed model.

Keywords: Micro grid, PV array, wind turbine, Biomass, HOMER.

I.INTRODUCTION

Renewable energy from photovoltaic, wind turbines and small hydro plants is highly suitable for off-grid electricity supply and has been successfully introduced in countless cases in developing countries. However, although the application of biomass as a sustainable electricity source seems promising, it is still seldom perceived as an option for providing electricity for the rural poor. Biogas is a fuel gas, a mixture consisting of 65% methane (CH4) and of 35% CO2.

Electricity consumption comprises different variables of diverse nature. The demand for this energy is expected to grow rapidly throughout the world, particularly in developing countries. Residential electrical energy consumption is about30-40% of the total energy use in different countries. While many of the renewable energy projects are of large scale, renewable technologies are also suited to rural and remote areas, where there is often crucial in human development. Renewable energy is derived from natural processes such as sunlight, wind, tides, geothermal that are

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replenished constantly. However, despite the apparent benefits, there has been little experience of implementing small electricity-generating biomass plants in off-grid areas of developing countries.
For homes currently relying on grid power, a renewable energy system has still more benefits. Power generated from renewable sources can be stored in a battery bank to provide backup power if utility power fails. In some areas alternative energy generated by a homeowner can be "sold back" to the local utility company, resulting in lower monthly electric bills at the least, and perhaps even generating income for the homeowner with a large renewable energy system. In developing countries, where rural electrification is developing, the application of photovoltaic (PV) systems is important. Extending power lines form centralized sources to rural areas is often not yet economical, and so, decentralized power sources, such as the PV system, is reliable alternative. One of the primary concerns in designing off- grid PV system involving PV array and storage battery capacity to supply the required energy at a specified energy load fraction[4]-[7]
The term off –grid refers to not being connected to main or national transmission grid in electricity [1]. This work involves using of a battery energy storage device, a micro grid, biogas generator and wind turbine to provide continues power supply. A lead acid battery is used as an energy storage device. Micro grids are the centralized alternative to distributed one to supply electrical energy to homes in isolated communities. Wind turbine and biogas is used as an optional alternative of generation of electric energy. The performance of a solar and wind system is evaluated through more accurate and practical mathematical methods.

II. MODERN HYBRID SYSTEMS

Modern Hybrid systems usually incorporate renewable energy sources to provide electrical power and used batteries as backup in case of lack of primary source without interruptions. They are generally independent of large centralized electric grids and are used in remote areas mostly for instance on a cloudy day and wind day, when the solar Panels are producing very poor levels of electricity, The wind generator and biomass generators can compensate by producing more electric power. The considerations can be taken as follows:

I. Systems based mainly on solar, Biomass and wind as renewable energy sources without grid.
II. Systems based mainly on solar, Biomass and wind as renewable energy source considering grid when there is shortage of power. If excess power is produced by the renewable energy it is given to the grid.

III. METHODOLOGY

1. Wind Energy & speed Estimation

Wind energy sources have the potential to significantly reduce fuel costs, greenhouse gas emissions, and natural habitat disturbances associated with conventional energy generation. Wind turbine generators (WTGs) are an ideal choice in developing countries where the most urgent need is to supply basic electricity in rural or isolated areas without any power infrastructure. Wind energy has become competitive with conventional forms of energy. Power system deregulation has opened opportunities for many private energy producers. Wind energy is a potential choice for smaller energy producers due to relatively short installation times, easy operating procedures, and different available incentives for investment in wind energy [1].
A good expression that is often recommended to model the behavior of the wind speed is Weibull PDF (Probability Density Function), as shown next
$f= (v) =(vc)k-1exp\lfloor-(vc)k\rfloor$ - - (1).
Where 'k' is shape index that is adjusted to match the wind speed profile of a site which is under study. While c is the scale index that is calculated based on the annual mean wind speed that is not constant from one year to another. The methodology proposed to estimate the annual wind speed profile is based on two steps utilizing three years of historical data. The first step is to divide the data into clusters. While in the second step, a constrained Grey predictor will be utilized to estimate the wind speed profile.

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2. Clustering of Data

Here, the data will be divided into clusters based on the seasonality of the wind. In order to reach a reasonable clustering outcome, three years of historical data for the site under study are utilized. By analysing the available data and calculating the correlation coefficient [9] among the wind speeds of the same period of time for different years, the following features were observed.

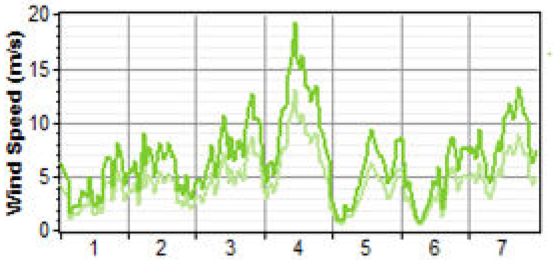

Figure 1: Wind speed profile during the same day on different years

IV. OPERATIONAL METHOD

The proposed hybrid energy system is incorporated of renewable source PV, Biomass and wind supply as in case study 1 and PV, wind and grid as in case study 2.Battery is acting the part of storage device charged by PV current. A Power Converter has been used for changing the source bus from DC to AC and vice versa. This integrated system is totally designed for supply electrification to the selected sample load. i.e., 48kWh/d, 5.6W peak loads.

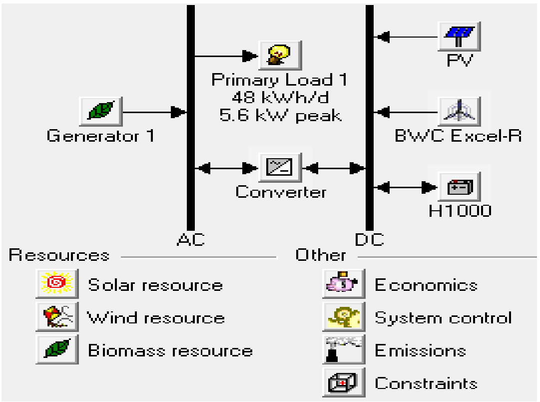

Figure 2: Hybrid power system configuration without grid

The location chosen for this study is college with latitude of 19°08′ North and longitudes 83°82′ East respectively. The load profile is acquired based on basic demands of utilities like Light, Cooling Fan, and other electrical apparatus and though most of the inhabitants of this land are doing academic activity. So, we have count weekdays and weekend separately for the load profile. Load is varied with seasonal and monthly consumption depending on climate.

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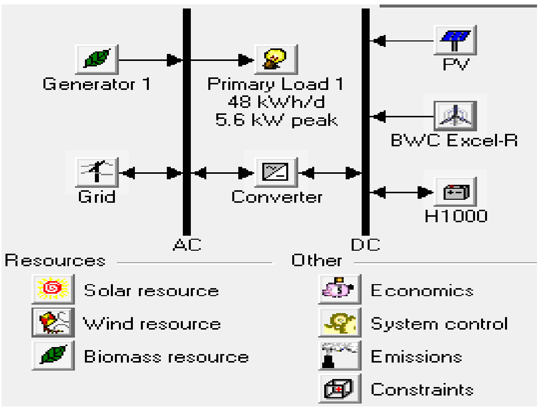

Figure 3: Hybrid power system configuration with grid

Total consumption of selected area load is 48KWh/d whereas the peak is 5.6KW. Here, the load is counted by yearly observation. The load profile will be the same in both case studies. The varying load profile of a year has been guided as following in Figure 4.

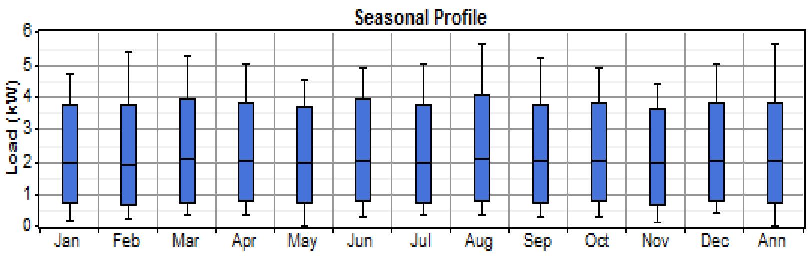

Figure 4: Yearly Load Profile

1. Resources Available for the selected Region

A. Global Horizontal Radiation and Cost of PV Inputs
With the chosen latitude and longitude HOMER software has automatically collected the global solar rate for the place like as shown in ref [10]. The average solar irradiation is 5.13 kWh / m2 /day. The site is located at GMT+05:30 Zone. The initial size of PV array used for this project is 6KW size [8]. Price for this capacity is retained at INR 541950/- and replacement cost is INR 540000/-. Different sensitivity variables have been used up to 10KW, as well as different PV azimuths have been set for a lifetime of20 years as shown in fig 5.

B. Wind Generator Cost Inputs
The initial size of the wind turbine used for this project is 7.5KW. Price for this capacity is retained at INR 900000 /- and replacement cost is INR 850000 /-. Different sensitivity variables have been used and wind turbine specifications have been set for a lifetime of 15 years. Fig.6 shows the wind resources and solar global radiation seasonally. With this latitude and longitude the wind speed has mentioned in HOMER software as seasonally for the place. The average wind speed is 5.16 m/s. The site is located at GMT+05:30 Zone. Fig.6 shows the wind resources.

C. Biogas Generator Cost Inputs
The initial size of the Biogas turbine used for this project is 6KW. Price for this capacity is retained at INR 1200000 /- and replacement cost is INR 1050000 /-. Different sensitivity variables have been used and Biogas turbine specifications have been set for a lifetime of 15000 hours. Fig.7 shows the monthly available biogas resources.

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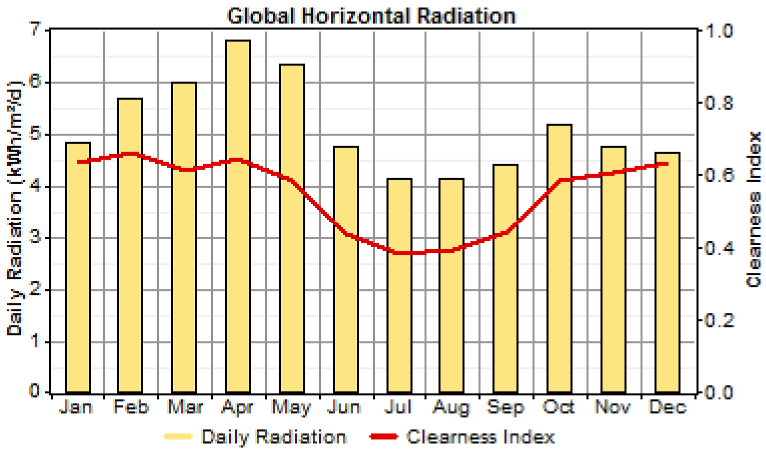

Figure 5: Average Monthly Solar Radiation

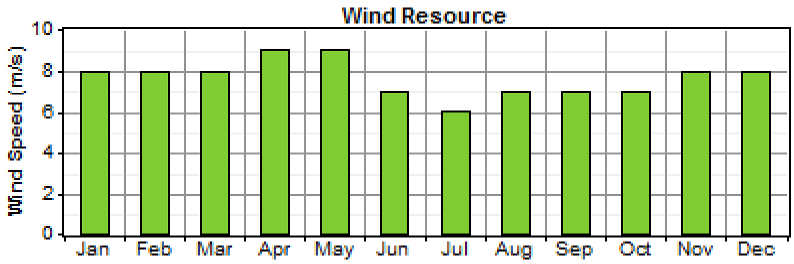

Figure 6: Monthly average wind speed

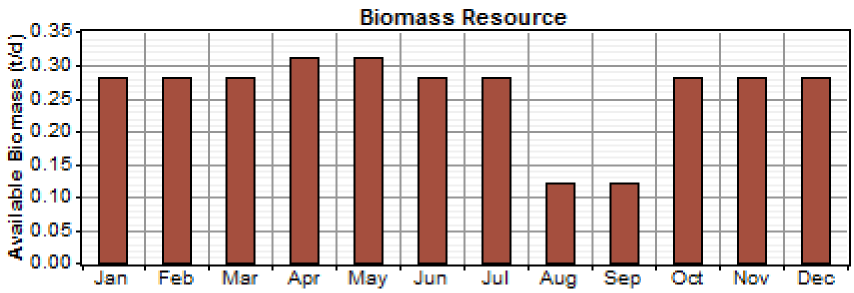

Figure 7: Monthly average Biomass resource

D. Battery

The[12] type of battery that used for the system is Hoppecke 10 opzs 1000 model with the rating of 2V, 1000Ah, 3438 kWh. The cost for one battery is INR 32,000/- with the replacement cost of INR 28,000/-. Fig.8 shows the life time cycle of failure and depth of discharge of a considered battery which is a key indicator for the project.

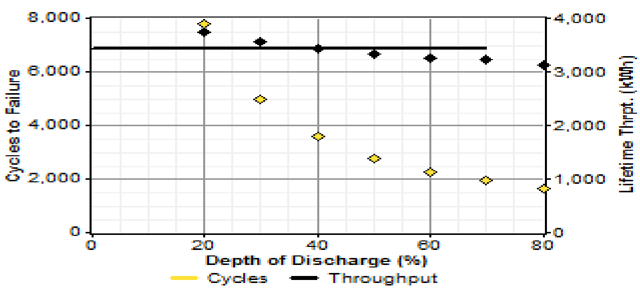

Figure 8: cycles of failure vs. Depth of Discharge

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V. ECONOMIC ANALYSIS OF THE HYBRID SYSTEM

Economic analysis [14]can be done by using the following relations. The annual cost of energy can be carried out by
COE =Cann, tot / (Eprim,ac+Eprim,Dc+Egrid,sales)
The total net present cost is HOMER's main economic
Output. HOMER computes the total NPC using the following equation:

CNPC= Cann, tot / [CRF (i, Rproj)]

Table 1.Gives the total NPC for grid and without Grid:

Component	Total NPC(INR)	Levelised COE(INR)	Operating cost(INR)
Without grid	53636700	36239/KWh	3637200/yr
With grid	3100800	13.85/KWh	24.3/yr

1. Cost Summary of the System

Case 1: Cost summary analysis of hybrid system without grid: Based on analysis, the system takes INR 53636700for capital investment .Total system cost including replacement and operational cost it need INR2000.the summary based on the total cash flow, categorized either by component or by cost type as in both cases are shown in fig 6.

Case2: Cost summary analysis of hybrid system with grid: Based on analysis the system takes INR6280/-for capital investment. Total system cost including replacement and operational cost it need INR12000.the summary based on the total cash flow, categorized either by component or by cost type as in both cases are shown in fig7.

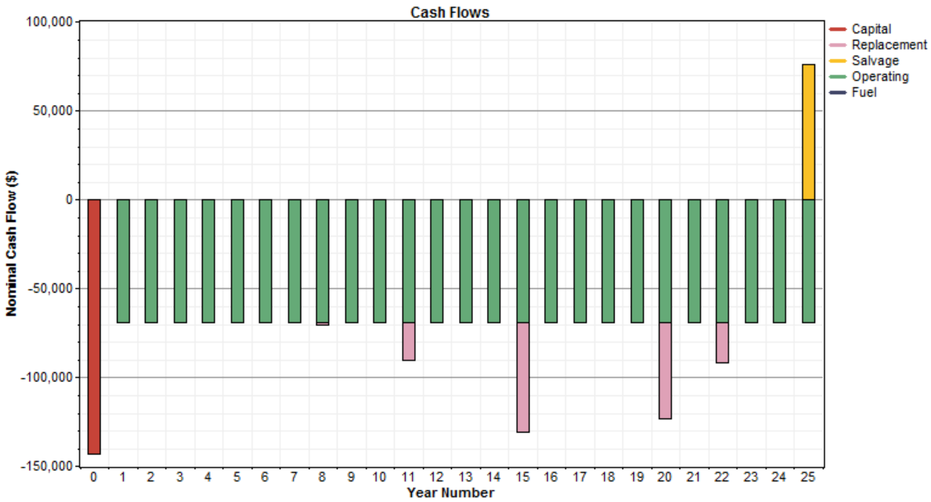

Figure.9: Cash flow summary without Grid

The figure 9 clearly showed monthly average Electric power production without Grid and here operating cost was more. In figure 10 clearly showed monthly average Electric power production with Grid and here operating cost was improved.

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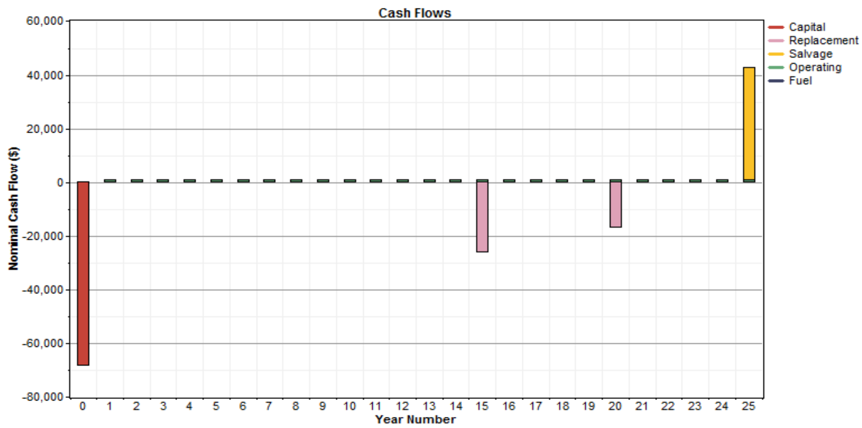

Fig.10: Cash flow summary with Grid

VI. OPERATIONAL STRATEGY OF POWER GENERATION

In this part of simulation identifying the details about the production and consumption of from hybrid system with and without grid is tabulated in table 2 and from the Table 3 the Excess electricity Production With and Without Grid can be calculated.

Table 2: Power Consumption from hybrid system with and without grid.

Load	With Grid		Without Grid	
	Consumption in KWh/Yr	Percent Fraction	Consumption in KWh/Yr	Percent fraction
AC Primary Load	17,520	62%	17,520	100 %
Grid Sales	10,659	38%	0	0%
Total	28,179	100%	6124	100 %

Table 3: Excess electricity Production With and Without Grid

Quantity	Value		Units
	Without Grid	With Grid	
Excess Electricity	64255	129	KWh/Yr
Unmet Load	0.0000727	0.00	KWh/Yr
Capacity Shortage	0.01	0.00	KWh/Yr
Renewable Fraction	1.00	0.838	KWh/Yr

By observing the above results, finding sufficient supplies of clean energy for the future is one of society's most discouraging challenges. Renewable energy sources will play a significant role in a sustainable development of the energy supply in the future, due to the minor impact they are expected to have on the environment and their large

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technological potential. But on the other hand, it still requires a great deal of technological and organizational development before it can contribute substantially to our energy needs in a sustainable way.
Photovoltaic Energy/Technology, Wind and Hybrid Energy Systems, Solar Thermal Energy from Waste and Biomass conjunction energy conservation and optimization technologies will be analyzed for site specific conditions to suit the particular load and how they can be integrated in to local grid[6].

VII. CONCLUSION

The results from HOMER software are realistic and give very promising results for on-grid homes. Institutions with integrated energy systems that depend heavily on grid power may be inspired to go for renewable energy sources. The success depends on a sincere and programmatic understanding of not only integrated energy system benefits, but also, the long term planning towards on-grid hybrid PV systems.

The three renewable energy sources, comprising photovoltaic system, a biogas turbine, a wind turbine are considered for on-grid institution. The simulation results shows potential results for favouring on-grid and the simulation results, found here can be a feasible solution for remote or isolated loads. Also, the consideration of carbon credits and subsidies for conventional fossil fuels may improve the efficiency and reliability to better extent. In this paper the systematic procedure towards to plan a hybrid powered institution integrated to a local grid is considered. Initially the scheme may be costly but, commercial use with the more customers of such systems can decrease the cost of technology and become economical for consumers.

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