HOMER Based Optimum Planning and Design of PV-Wind Hybrid Renewable Energy System

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Abstract—This paper presents the preliminary optimum planning and design of PV-Wind hybrid energy system for a rural area of India. Optimization of any hybrid system is the process of selecting the suitable components and its sizing with proper operation strategy to provide eco-friendly, efficient, reliable and cost effective alternative energy to the society. Hence for design of hybrid system solar radiation, hourly wind speed are taken for latitude 20° 24' and longitude 78° 8' and the energy consumption pattern of load are studied from analogy with survey for a particular site. The system has been simulated by using National Renewable energy laboratory developed HOMER software. The simulation and optimization result gives the best optimized sizing of wind turbine and solar array with good battery backup. The system is more cost effective and environmental friendly.

Index Term - Battery; Converter; HOMER; Hybrid System; Renewable energy system; Optimization; PV-Wind.

I. INTRODUCTION

Due to global warming and depletion of fossil fuels in the world peoples are now look towards the alternative sources of energy like solar, wind biomass etc. as these are freely available & non-polluting. In comparison with other renewable based system the growth of photovoltaic system become slow due to its high capital cost. In recent years due to advance material and better manufacturing process have decreased their capital cost making them more attractive. Another way to attempt to decrease the cost of these systems by making use of hybrid designs that uses both wind and photovoltaic. Commonly hybrid energy system uses solar, wind and hydro energy sources, although most of the renewable energy available on earth consists of different forms of solar energy. A system of the combination of these different sources has the advantage of the balance and stability [1]. The use of renewable energy sources presents a tremendous potential for many applications especially off-grid stand alone systems. In this context, one of the most promising applications is the installation of hybrid renewable energy systems in remote areas [2]. As per the review of different research paper on hybrid energy system indicates that it’s an excellent solution for the remote areas where the grid extension is difficult and uneconomical [3] [4] [5] [6]. Hybrid system is a combination of two or more different type of energy resources which together ally works and give the optimum output by utilizing the available natural resources in the surrounding. But the design of hybrid renewable energy system becomes a challenging task as the coordination among renewable energy sources, generators, energy storage and loads very complicated [7] [8]. Hence optimum planning of such system is very essential before its construction.

In this paper the simulation of hybrid energy system composed of PV together with wind turbines, battery storage and inverter has been discuss and presented.

II. SYSTEM DISCRITION

In order to size and select renewable energy systems for rural electrification it is necessary to estimate load profile and energy resources information for a particular site.

A. Load Profile

To determine electricity demand the appliance ownership data can be obtained by analogy with survey. The objectives of questioner survey are

1. To have an overview of existing living pattern of the peoples.
2. To identify income class distribution for the village.
3. To identify energy use pattern.
4. To identify problems and limitation of the existing methods.
5. To identify relevant methodologies for effective electricity demand estimation.
For data analysis the load profile of Dudhagon village in Yavatmal District, Maharashtra, India has to be considered. By referring to the load profile shown in fig 1 730 Kwh/day is the average estimation of daily energy consumption and peak requirement of the load is about 134 Kw peak.

![Fig. 1. Daily average load for a complete year](image)

**B. Solar Resource Input**

Solar resource input for the propose site for latitude 20° 24'N and longitude 78° 8'E are collected from [9]. Fig 2 represents the annual average daily radiation for this site is 5.312 Kwh/m²/day.

![Fig. 2. Solar Resource input](image)

**C. Wind Resource Input**

The second resource for hybrid renewable energy system is the wind. The average monthly wind speed data are collected from [10] and it is found that annual average wind speed is 3.22m/s shown in fig 3.

![Fig. 3. Wind resource Input](image)

D. Optimum Planning of Hybrid Energy system

In this work optimum planning of hybrid energy system has been done using National Renewable Energy Laboratory’s develop HOMER software. It is most popularly used hybrid system design software that facilitates design of electric power systems for rural applications. Input requirement to the HOMER includes; hourly electrical loads information, renewable resources input as daily solar radiation, monthly wind speed, component technical details and cost, constraints, control etc [11].

HOMER is a simplified optimization model which performs hundreds or thousands of hourly simulation over and over in order to design the optimum system.

**III. HOMER SIMULATION MODEL**

The system model has been consists of PV WG, Batteries and converter shown in fig 4. In order to find out the system performance of hybrid energy system under various situation number of hourly simulation have been carried out. In this study the decision variable include

1. The number of the pv array
2. The no of wind generator
3. The capacity of energy storage
4. VA rating of the AC/DC converter

![Fig. 4. HOMER simulated Model of PV-Wind system](image)

In normal operation PV & wind turbine feed the load demand. The excess energy from PV and WG is stored in the battery until full capacity of battery is reached. The main importance of introducing energy storage is to import/export energy depending upon the situation. The technical details of proposed HRES are
RESULTS AND DISCUSSION

Several simulations have been made by considering PV capacities and the no of WG. The PV capacity has been allowed to vary from 0-200 KW and no of WG has been allowed to vary from 0-3. The battery storage sizes considered include 0-6 hours of average load.

From the results shown in fig 5. It is clear that the first system consists of PV/WG/Batteries/Converter is the most commercial & economical system. The annual electric energy production is 452049 Kwh/yr out of which PV contributes 66% & wind system contributes 34% shown in fig 6.

<table>
<thead>
<tr>
<th>Production</th>
<th>kWh/yr</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV array</td>
<td>293,459</td>
<td>66</td>
</tr>
<tr>
<td>Wind turbines</td>
<td>152,590</td>
<td>34</td>
</tr>
<tr>
<td>Total</td>
<td>446,049</td>
<td>100</td>
</tr>
</tbody>
</table>

The annual energy consumption is 266387 Kwh/yr, the excess energy is about 130547 Kwh/yr, and unmet electric load is only 62.8 Kwh/yr nearly 0%. Fig 7 shows the excess electrical production monthly average which is about 28.9% per year. Fig 8 shows the PV system output rated capacity is about 180KW and mean output is 34 Kw and 120 Kwh/day. Similarly fig 9 shows the wind turbine output having total rated capacity is 500KW and means output is 17KW.
CONCLUSION

The simulation results indicates that a hybrid energy system consist of 180 (Kwpeak) photovoltaic system with two 250 (KW) wind generator system and battery storage would be an economical solution for generation of electric energy for rural application.

The cost of generating energy for hybrid system has been found 0.818 $/Kwh. The system offer several benefits such as utilization rate of PV generation is high, load can be satisfied in the optimal way.

Excess electricity is about 28.9% that can be minimizing by adding a large capacity of battery storage with converter which could leads to reducing the COE.

REFERENCES


