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Research Paper

DESIGN AND MODELLING OF WIND-SOLAR-DIESEL (BIO) HYBRID ENERGY SYSTEM

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There is a need for alternative sustainable electric power supply system to provide electricity to rural and remote located communities. Designing a hybrid energy system with available energy sources is a complex job that involves energy resource assessment, load dispatch management, optimal design of hybrid system that would reduce overall capital cost and has a better payback. Energy resource assessment involves study of renewable energy resources at that particular location by taking scientific data into account. Load dispatch management involves studying various load patterns such as water pumping for agriculture, library building, police stations and telephone towers. Optimal design of hybrid energy system involves the definition of optimization function for the overall energy system w.r.t to cost, energy yield and minimization of grid dependence. In this work it is proposed to develop guidelines, design environment and modeling tool for the design and integration of solar, wind, diesel or biodiesel hybrid energy system for any building. PVSYST & HOMER are used for developing various models. Performance of hybrid energy system can also be evaluated.

Keywords: Hybrid energy, Design and modelling, Sustainable electric power

INTRODUCTION

Renewable energy technologies offer the promise of clean, abundant energy gathered from self renewing resources such as sun, wind, water, earth and plants. Virtually all regions of the world have renewable resources of one type or other.

Renewable energy technologies offer important benefits compared to those of conventional energy sources. Worldwide 1000 times more energy reaches the surface of the earth from the sun than is released today by consuming all fossil fuels. Photo voltaic and wind generation are also an attractive source of energy.

A combination of two or more energy sources is more effective than a single source system in terms of cost, efficiency and reliability. It can easily

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reduce need of fossil fuel by properly choosing the combination of renewable energy sources.

The combination of two or more energy sources is known as Hybrid energy system. Hybrid system provides a high level energy security through the mix of generation methods and often will incorporate a storage system (Battery) to ensure maximum supply reliability and security. Wind turbines and solar panels are most well known of renewable energy devices used in Hybrid power systems.

However with all the advantages of electric power system consisting of solar and wind as primary sources possess some technical difficulties due to uncontrollable weather data like wind speed fluctuations and the day and night, summer and winter sun conditions. As a consequence of this the power supply continuity should maintained by back up by alternate reliable and non-fluctuant energy sources such as diesel generator, battery, etc.

In this paper it is considered a 60 Kw system for a building, for that a hybrid system is designed and modeled using PV SYST,HOMER. The combination of Photo Voltaic (PV) array system, Wind turbine system and Diesel generation system are used for power generation, blocks like wind model, PV model, Diesel generator, battery, energy conversion system and load are implemented and the results are also presented.

MODELLING THE COMPONENTS OF HYBRID SYSTEM

Modelling of PV Module

Photo voltaic or PV cells, commonly known as solar cells, basically convert the energy from sunlight to DC electricity, and then it converts DC into AC with DC-DC converters and inverters. The preliminary design of pv system is done in PV SYST. It is shown in Figure 1.

Figure 1: Preliminary Design of pv System in PV SYST

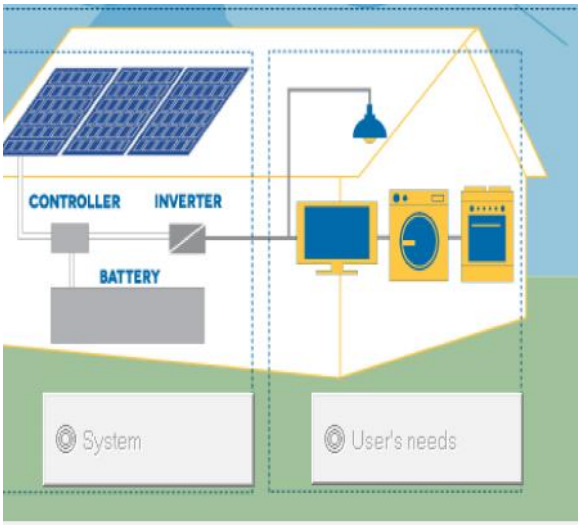


Table 1: The Monthly Irradiation Data for Ananthapuramu

Meteo for Anantapur, Reference Year		
Interval Beginning	GlobHor	DiffHor
	KWh/m^2	KWh/m^2
January	163.1	40.61
February	171.1	38.64
March	202.7	51.46
April	196.5	59.4
May	192.2	66.03
June	154.2	69
July	144.8	72.54
August	146	72.85
September	150	65.1
October	144.8	59.52
November	138	48.3
December	147.2	42.16
Year	1950.6	685.61

The PV SYST analyses PV system and the irradiation data is synthetic data. In this system Generic flat plate PV of capacity 30 Kw is used.

Figure 2: Hourly Irradiation vs Energy

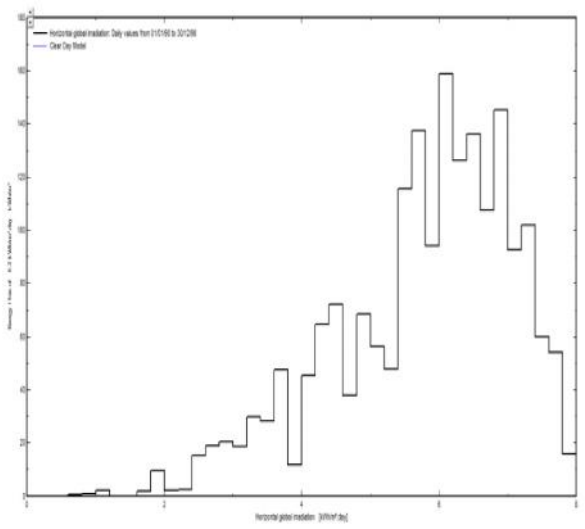


Table 2: Monthly Average Daily Radiation and Clearness Index for Ananthapuramu

	Index	(kWh/m^2/day)
January	0.666	5.48
February	0.644	5.84
March	0.582	5.81
April	0.54	5.7
May	0.504	5.39
June	0.516	5.5
July	0.516	5.49
August	0.526	5.55
September	0.578	5.85
October	0.607	5.64
November	0.644	5.4
December	0.668	5.3
Annual Average (kWh/m^2/day): 5.58		

Modelling of Wind Turbine

30 KW Generic wind turbine is proposed in this system

Table 3: The Monthly Average Wind Speed in Ananthapuramu

Monthly Average Wind Speed	
Month	**Average (m/s)**
January	3.59
February	3.68
March	3.49
April	3.56
May	4.22
June	5.21
July	4.69
August	4.3
September	4.4
October	4.56
November	4.57
December	4.09
Annual Average (m/s): 4.20	

Wind energy is the kinetic energy of the moving air mass. The power, *P*, in watts, possessed by wind blowing with a speed of *V*, in meter per second (m/s), is directly proportional to the area swept by rotor and to the cube of the wind speed, and is given by,

$$P = \rho . A . V^3 / 2$$

where, *A* is the area perpendicular to the direction of flow (m^2), is density of air, kg/m^3, is approximately 1.2 kg/m^3.

Diesel Generator

In this system 50 KW Diesel generator is used and in which biodiesel is used as fuel.

OPTIMAL DESIGN OF HYBRID SYSTEM IN HOMER

The proposed system consists of PV modules, batteries, charge controller, inverter, and the necessary wiring and safety devices. The system feasibility analysis is performed using the HOMER

software. HOMER is a computer model that simplifies the task of evaluating design options for both off-grid and grid-connected power systems for remote, stand-alone, and Distributed-Generation (DG) applications.

HOMER's optimization and sensitivity analysis algorithms allow one to evaluate the economic and technical feasibility of a large number of technology options and to account for variation in technology costs and energy resource availability. HOMER allows the modeler to compare many different design options based on the technical and economic merits.

Figure 3: Block Diagram of the Hybrid System

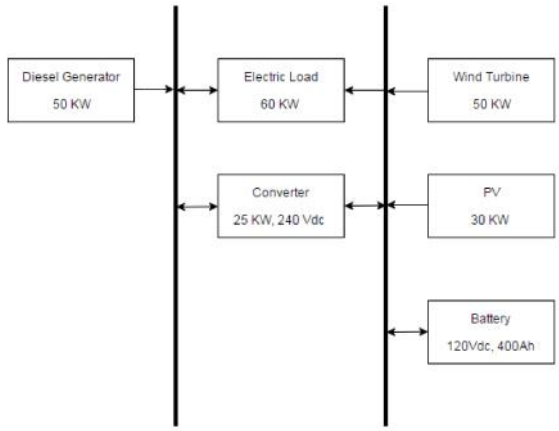


Table 4: Load Data

S. No	Name of Appliance	Capacity Watt	No. of Appliances in Use	No.of Operating Hours (hr)	Total Energy (KWh)
1	Fluorescent lamps	40	60	6	14400
2	Fans	70	50	6	21000
3	Computers	120	20	2	4800
4	Water pump 5HP	5000	1	2	10000
5	Air conditioner	1500	4	2	12000
Total					62200

Load Data

A typical lightning load consisting of 60 LED bulbs and 50 fans, 20 computers, 1 5HP pump, 4 air conditioners, etc.

Cost Analysis

Table 5: Cost Analysis

S. No	Name of Item	Rated Capacity	Cost (in lakhs)
1	Diesel Generator	50 Kva	22
2	PV System	30 KW	24
3	Wind Turbine	30 KW	25
4	Battery	120 Vdc ,400 Ah	4
5	Converter	25 KW, 240Vdc	25
Total			100

The total capital cost of the system is 1,00,00,000 Rs.

Payback Analysis

The number of units generated per KW = 4 KWh

The number of units generated per 60 KW = 240 KWh

Tariff per KWh = 7 Rs

Tariff per day = 240*7

= 1680 Rs

Tariff per year = 6,04,800 Rs

Payback period = 1,00,00,000/6,04,800

=16.53 years (16 years 6 months 13 days)

RESULTS

HOMER Results

Figure 5: Daily Radiation vs Time Clearness Index

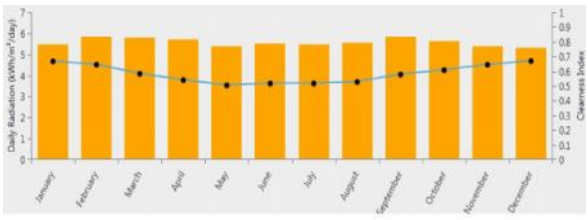


Figure 6: Power Output vs Wind Speed

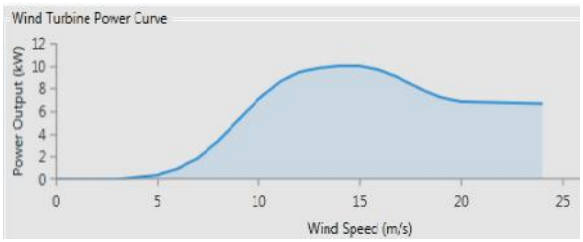


Figure 7: Yearly Profile

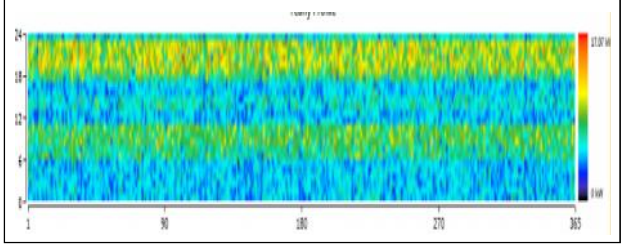


Figure 8: Daily Load

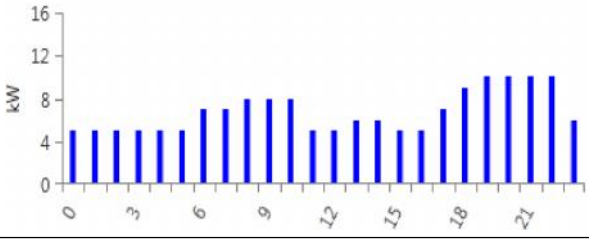
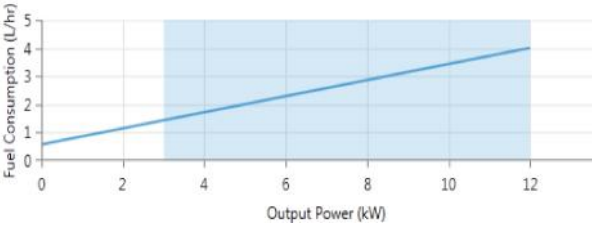


Figure 9: Average Wind Speed vs Time

Figure 10: Fuel Consumption vs Output Power



PV SYST Rresults

Figure 6: Power Output vs Wind Speed

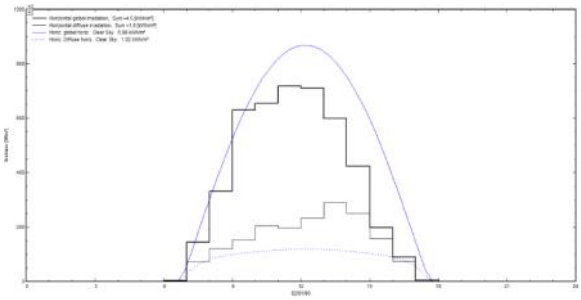


Table 6: Average Monthly Clearness Index, Ambient Temperature, Global Radiation

Interval Beginning	Glob Hor KWh/m^2. mth	KT	T Amb ^{0}c
January	163.1	0.631	24
February	171.1	0.664	27
March	202.7	0.649	30.1
April	196.5	0.618	30
May	192.2	0.579	29.1
June	154.2	0.482	26.5
July	144.8	0.439	25.8
August	146	0.445	25.8
September	150	0.489	26.2
October	144.8	0.494	25.5
November	138	0.539	24.2
December	147.2	0.593	23.29
Year	1950.6	0.548	26.45

CONCLUSION

In this project the Hybrid system with the combination of solar/wind/diesel (bio) system. PV system has been designed and modeled Using PV SYST software computer model to supply 30 KW Lightning load for a building. It has been discussed here that the stand alone Hybrid system is designed by integrating 30 KW Photo voltaic (PV) system, 30 KW wind turbine, 50 KW diesel generator, battery(120 Vdc,400 Ah) ,convertor (25 KW, 400 Vdc). The battery system can provide 6 hours of backup supply.

The hybrid energy system optimization is done in HOMER Compared to any fossil fuel based system the running cost of the proposed system is very low and capital cost of the system is 1,00,00,000.The payback period for the system is 16 years 6 months 13 days. Integrators or vendors can apply this for optimal design of the renewable energy system in the renewable industry.

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