Optimization of Solar-Wind Hybrid System for Distributed Generation

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Abstract**-- A wind-solar hybrid system is a reliable alternative energy source because it uses solar energy combined with wind energy to create a stand-alone energy source that is both dependable and consistent. Solar power or wind power alone can fluctuate, when used together they provide a reliable source of energy. The perfect solution is to combine these two forms of energy sources to create a constant energy flow. Main objective of this paper is to optimize stand-alone solar-wind hybrid power system and to maximize use of renewable energy generation system while minimizing the total system cost.**

Index Terms**—Homer, Hybrid System, Optimization, Solar, Wind**

I. Introduction

SOLAR energy and wind energy have been deemed clean, inexhaustible, unlimited, and environmental friendly . Such characteristics have attracted the energy sector to use renewable energy sources on a larger scale. However, all renewable energy sources have drawbacks. Wind and solar sources is dependent on unpredictable factors such as weather and climatic conditions. Due to both sources' complementary nature, some of these problems can be overcome the weaknesses of one with the strengths of the other . This brings us to the hybrid solar-wind power plant concept. Hybrid energy stations have proven to be advantageous for decreasing the depletion rate of fossil fuels, as well as supplying energy to remote rural areas, without harming the environment.

Distributed Generation (DG) refers to small power plants (a few watts upto 1MW) at or near the loads, operating in a stand-alone mode or connected to a grid at the distribution or sub-transmission level, and geographically scattered throughout the service area. Distributed Generation includes small, modular technologies for electricity generation, located close to the load. DG technologies are used both in stand-alone mode as well as in grid parallel mode. Conventional electricity generating stations are typically located close to the fuel source and away from the loads, and electricity generated is conveyed through the transmission system to the load centre, which often requires large investment. Transmission and distribution costs account for about 30 per cent of the cost of delivered electricity. DG technologies obviate the need for an expensive transmission system and minimize transmission and distribution losses.

The Hybrid Optimization Model for Electric Renewables (HOMER) software is used as a tool to carry out the research. The main objective of this paper is to assess the feasibility and economic viability of utilizing hybrid Solar–Wind–battery based standalone power supply systems to meet the load requirements.

II. Wind Power

Wind is a natural phenomenon related to the movement of air masses caused primarily by the differential solar heating of the earth's surface. Seasonal variations in the energy received from the sun affect the strength and direction of the wind.

The wind turbine captures the winds kinetic energy in a rotor consisting of two or more blades mechanically coupled to an electrical generator. The turbine is mounted on a tall tower to enhance the energy capture.

III. Solar Power

The solar modules (photovoltaic cell) generate DC electricity whenever sunlight falls in solar cells. The solar modules should be tilted at an optimum angle for that particular location, face due south, and should not be shaded at any time of the day.

IV. Hybrid Solar-Wind system

A stand-alone wind system with solar photovoltaic system is the best hybrid combination of all renewable energy systems and is suitable for most of the applications, taking care of seasonal changes.

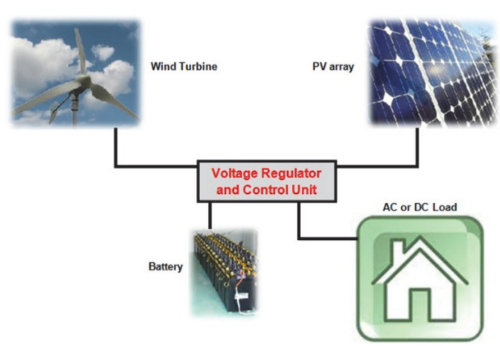

Fig:1 Solar-wind hybrid power system

They also complement each other during lean periods, for example, additional energy production through wind during monsoon months compensate the less output generated by solar. Similarly, during winter when the wind is dull, solar photovoltaic takes over. The hybrid solar wind power system is as shown in figure 1.

Application:

- Remote and rural village electrification
- Ideal for cell phone recipient stations,
- Residential colonies and apartments for general lighting
- Street lighting

V. ANALYSIS METHOD

The HOMER is a micro power optimization software developed by Mistaya Engineering, Canada for the National Renewable Energy Laboratory (NREL) USA, which can useful for evaluating designs by simplifying the given task for both off-grid and grid-connected power systems for plenty of applications . It also provides the cost benefit analysis for hybrid energy system. In designing any power system, the decisions about the configuration of this system needs to be analysed, like components and its specification for the system design, size of that all components, the availability of energy resources and technological options, and the cost of each available technology, all these information are difficult to achieve.

HOMER simulations are performed by analyzing energy balance calculations and show the all possible configurations. This all possible configuration arranged by net present cost which can be useful for comparison of system design. HOMER's optimization and sensitivity analysis make this task easier. Also it finds all possible system configurations related to it

The site is selected for analysis is Vadodara which has latitude $22^{0}19'$ North and longitude $73^{0}14'$ East. Solar radiation data for tilted panel and average wind speed data at 50 m above the surface of the earth is taken from NASA website.

Average wind speed: 3.74 m/sec
Average solar radiation: 5.53 $KWh/m^2/day$

TABLE I
WIND AND SOLAR DATA

Month	Solar radiation ($KWh/m^2/day$)	Wind speed (m/s)
January	6.15	3.53
February	6.49	3.58
March	6.49	3.72
April	6.06	4.18
May	5.42	4.82
June	5.29	5.12
July	3.77	4.38
August	3.76	3.69
September	4.88	3.49
October	6.01	2.71
November	6.33	2.68
December	5.80	3.03

VI. SIMULATION

We consider three different system i.e. solar power system, wind power system, solar-wind hybrid power system. Here we consider ac load for simulation.

Components to be considered for stand alone solar power system and stand alone wind power system.

Wind turbine :

Type: Generic 1 KW
Rated power: 1 KW DC
Life time: 15years
Hub Height: 25m

PV panel:

Slope: 30
Lifetime: 20years

Battery:

For solar power system and hybrid power system

Type:Vision 6FM 200D
Nominal Capacity: 200Ah
Nominal Voltage: 12V

For wind power system

Type:Hoppecke 10opzs 1000
Nominal capacity:1000Ah
Nominal voltage: 2V

Primary load

Type: AC
Rating: 5 KWh/day

TABLE II
COST TABLE

Equipement	Rating	Cost in Rs
Solar panel	1KW	350000
Wind turbine	1KW	84000
Converter	1KW	12500
Battery	12V,200Ah	10000

A. STAND ALONE SOLAR POWER SYSTEM

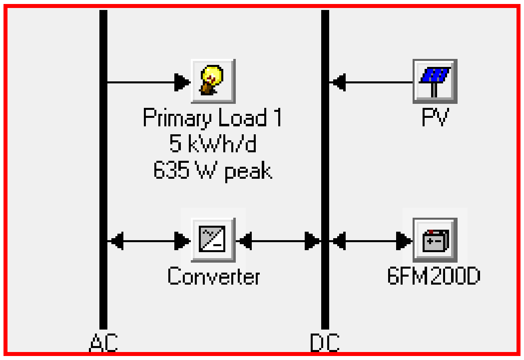

Fig. 2. Model of Solar Power System

B. STAND ALONE WIND POWER SYSTEM

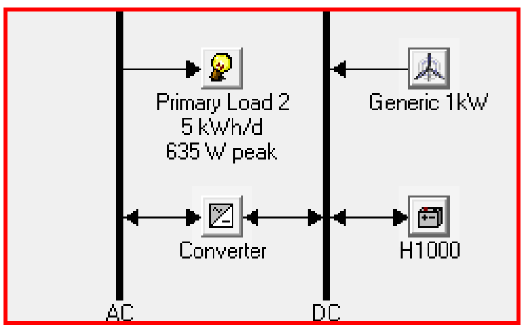

Fig. 3. Model of Wind Power System

C. STAND-ALONE SOLAR WIND HYBRID POWER SYSTEM

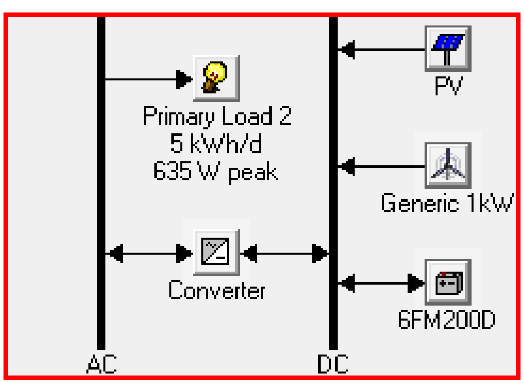

Fig. 4. Model of hybird Power System

TABLE III
COMPARISON OF COSTS

System	Initial capital ($)	Operating cost ($/year)	Total NPC ($)	Cost of energy($/KWh)
Solar power system	23301	1069	36964	1.572
Wind power system	32700	2823	68783	2.923
Hybrid power system	17784	875	28975	1.232

VII. ANALYSIS OF RESULTS

The below mentioned results declair that the proposed stand-alone hybrid system will be able to feed the power to the ac load of rating 5 KWh/day, constantly throughout the year. The proposed system is best suitable for ac load. The sensitivity variables considered for the proposed system analysis of stand-alone hybrid system are wind speed, solar irradiation, fuel cost and Battery cost. The simulation results are evaluated for each one of this sensitivity. An hourly time series simulation for every possible configuration system is achieved for the 1-year period. From all suggested configuration, the best optimal system is kept, which fullfils the condition of meeting the load demand.

Analysis based on breakeven grid extension distance:

This analysis shows the comparison between grid extension and stand alone system based on total net present cost.

For solar power system: 3.45km

For wind power system: 6.61km

For solar-wind hybrid power system: 2.65km

Optimization Result

After analyzing the simulation, one can suggest that the stand-alone solar-wind hybrid system is most suitable compared to the other configuration, for supplying the power to the ac load. The simulation result suggests that this hybrid system is most suitable for Vadodara location. Result suggests that from the different possible configuration, one can choose the better optimal solution. From the optimization results the most suited optimal configuration of energy system components are Generic 1KW wind turbine, 2 KW PV-Array. From the result, the total net present cost (NPC), Initial cost, operating cost and cost of energy (COE) for such a system is $28975, $17784, $875 and 1.232$/kWh, respectively for one year as shown in table II.

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VIII. SIMULATION RESULTS

The simulation result allows only feasible solution with their increasing in number of cost and eliminates all other infeasible possible solutions. Also simulation performs the number of parameters displayed agianst sensitivity variables to identify optimal solution for energy system. The Monthly Average Electricity Production of Stand-alone Hybrid Energy System for is shown in Figure 5.1. According to the optimal solution the total energy required to satisfy the laod demand by the hybrid combination of 82% PV, 18%wind.

Production	kWh/yr	%
PV array	3,005	82
Wind turbine	660	18
Total	3,665	100

Consumption	kWh/yr	%
AC primary load	1,840	100
Total	1,840	100

Quantity	kWh/yr	%
Excess electricity	1,419	38.7
Unmet electric load	0.564	0.0
Capacity shortage	0.919	0.0

Quantity	Value
Renewable fraction	1.00

Fig. 5.1 Result for hybrid solar-wind power system

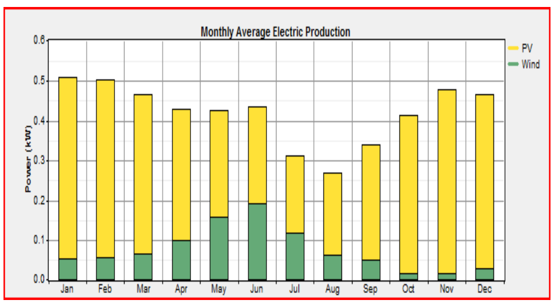

Fig. 5.2 Graphical representation of result for hybrid solar-wind power system

Figure 5.2 shows monthly average electric production from wind energy and solar energy in graph format. Yellow colour indicates electric energy production from solar energy and green colour indicates electric energy production from wind energy.

IX. CONCLUSION

In rural or remote sites the above proposed renewable base stand-alone solar-wind hybrid system is most suitable solution. These solutions for this proposed system are cost effective and available throughout the year. The circumstance of Vadodara site is studied in order to decide the feasible combination of alternative energy resources. Form the above pre-feasibility study the solar and wind hybrid energy system are most suitable power solution over conventional diesel generator. With the use of proposed renewable energy base system the emission of carbon and other harmful gases are reduced to approximately 80% to 90% in environments.

Although initial cost for solar-wind hybrid power system is high, but it produces electricity at least cost. Due to distributed generation it eliminates installation cost transmission lines. It has many advantages that it produces no pollution and requires less maintenance. HOMER software is used for the optimization of hybrid combination and gives best combination according to least price. For Vadodara hybrid system produces electricity 61% from PV cell and rest 39% from wind energy.

X. REFRENCES

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