HOMER OPTIMIZATION BASED SOLAR WIND HYBRID SYSTEM

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Abstract-Operation of telecom networks require extensive use of diesel generators for power supply, which has lead to a disadvantage of increasing the greenhouse gas emission and enlargement of carbon footprints. To avoid these effects we are using solar and wind hybrid system. As there is adequate availability of solar energy and average wind speed, we are utilizing solar and wind power hybrid system with durable battery backup for providing reliable cellular mobile services. A microcontroller is used to monitor the power from solar panel and wind generator. The switching action is provided from microcontroller to the battery charger based on power received from solar panel and wind generator. For the optimal planning of sizing of different components of system the simulation software HOMER (Hybrid Optimization Model for Electric Renewable) is used.

Keywords —HOMER, Hybrid System, Optimization, Solar, Telecom Network, Wind.

I. INTRODUCTION

The Indian telecom sector has grown expeditiously in last decade and still expected to grow intensively. In present days, the mobile operators are undergoing serious difficulty in limiting financial loss. At the same time, there has been an increase in cost due to higher cost of spectrum as well as the lack of reliable 24x7 grid power [2]. One solution to solve this problem is to bring down the operation costs. In the absence of poor and unreliable electrical power infrastructure, these operation costs are influence over energy costs at the cell sites. As the network expands more into rural areas, the cost of cellular network rises further as the power shortage increases.

More than 70% of the 400,000 Base Transceiver Sites (BTS) sites in India are faced with the lack of power supply for over 8 hours a day; many face much larger power cuts[2]. During power cuts, the telecom operators have to power cell sites with diesel generators and battery backups, which to day have excessive costs. The Indian telecom industry absorbs more than 2 billion litres of diesel and discharges 5 metric tons of CO2. Hence if the telecom industry has to expand in the rural areas, there is need for an alternative sources of energy. The alternative to cut the cost is to use renewable sources of energy to power mobile base station.

Powering BTS sites with diesel have two adverse implications

1. High Costs: The cost involved in using diesel is very high and it is estimated that the Indian telecom industry spends over 85 billion rupees on diesel every year [3].

2. The depletion of a non renewable energy source which leads to high carbon footprints and is hazardous for the environment [4].

The use of renewable energy sources like solar energy and wind energy can be explored as a feasible option for replacing diesel in powering the BTS sites worldwide and specifically in India. The more suitable form of renewable energy in today's world is the solar energy and wind energy. The solar electric system converts sun radiation into DC electricity. To get usable electric voltages the solar cells are connected in series parallel combination. The wind energy is utilized for power generation by converting the kinetic energy of wind in to rotational motion by using a wind turbine. This rotational motion is converted into usable electrical energy. Solar and wind energy are clean, environmental friendly. Because of this advantages they are used by energy sectors.

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However, they have some drawbacks. Wind and solar energy depend on weather and climate conditions. Solar energy is not available for 24 hours and wind is not continuous at all time. So, solar wind hybrid system is used. The solar wind hybrid system provides power periodically. Microcontroller is used to monitor power from wind turbine and solar panel and the switching action is provided from microcontroller to the charge controller based upon power received from solar panel and wind turbine.

For the optimal planning of sizing of different components of system the simulation software HOMER (Hybrid Optimization Model for Electric Renewable) is used . HOMER performs the energy balance calculation for each system configuration. PV array system, wind turbine, diesel generator with battery and converter are the components chosen for the analysis. HOMER simulates the system based on the estimation of installing cost, replacement cost, operation and maintenance cost, fuel and interest.

II. BASE STATION POWERED BY RENEWABLE ENERGY

Mobile communication technologies such as base station and mobile phones have become very common technologies throughout the world. Roughly three billion users spend large portion of their income on these communication technologies. However, the remaining half of the world currently has limited access, in large part due to poor network. Mobile telecom networks require an excessive amount of power. The Indian telecom industry absorbs more than 2 billion litters of diesel and discharges 5 metric tons of CO_2. The alternatives to improve base-station efficiency are solar powered base station and wind powered base station. The use of diesel generators to power base-stations requires regular maintenance, are expensive to run, and cause air pollution. By utilizing solar power to run the base-stations reduce the operational cost. Due to expressive increase in power demand for future mobile networks (LTE, 4G and 5G) wind powered base station has become an effective solution to reduce fossil fuel consumption. The systems with only solar or wind generation are productive but there are problems linked with both of them. The solar power is not available for 24 hours and wind is not continuous all the time. So a hybrid system containing solar and wind has been designed to overcome these problems. A stand-alone wind system with solar photovoltaic system is the best hybrid combination of all renewable energy systems.

III. ANALYSIS METHOD

The Hybrid Optimization Model for Electrical Renewable (HOMER) software developed by Misty Engineering, Canada for the National Renewable Energy Laboratory USA. For the optimal planning of sizing of different components of system the simulation software HOMER is used. HOMER performs the energy balance calculation for each system configuration. PV array system, wind turbine, diesel generator with battery and converter are the components chosen for the analysis.

Fig.1 shows the geographical location of the study area on the map. The study area under consideration is located in the Pune district of Maharashtra state, India. Narhe is located between 18 ^{0}27.1'N latitudes and 73 ^{0}49.7'E longitudes.

Fig.1 Study Area

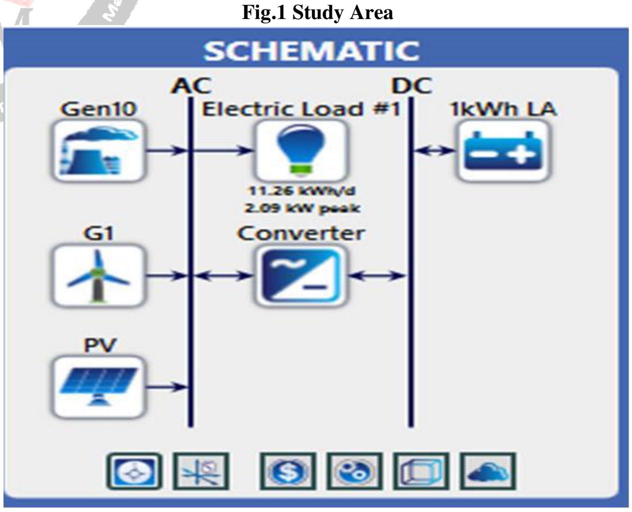

Fig.2 Homer Schematic

Fig.2 shows HOMER schematic for this project. The size of Wind generator is 10Kw, size of solar panel is 1Kw, battery used is generic 1Kwh lead acid battery, and converter used is generic 1kw converter.

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IV. SYSTEM SIZING

The Hybrid energy system sizing is done in Hybrid Optimization Model For Electrical Renewable (HOMER) software. The proposed system comprises primary renewable sources (Wind/PV) which are placed with a standby secondary non-renewable sources (Diesel Generator/Batteries), and converter is included in the system to connect between AC and DC link [1].

A. WIND TURBINE

Wind turbine has rated capacity of 1kW. The Cost of one unit is considered to be, capital cost is estimated as 7000$, replacement cost is estimated as 7000$, and annual operation and maintenance cost is estimated as 70$. The simulation program find an optimum solution, lifetime of a turbine is taken to be 20 years. The Hub height is 17m.The power curve in show in fig.3 and the wind resource show in fig.4.

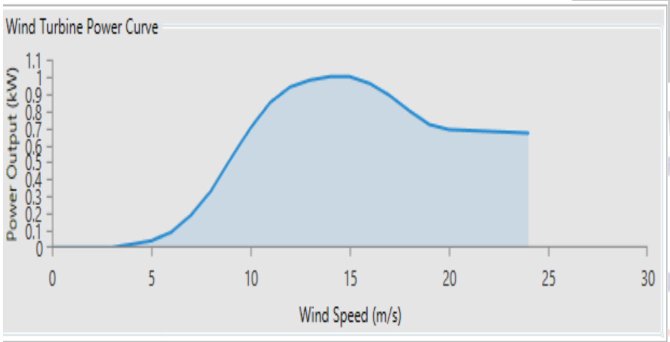

Fig.3 Wind Turbine Power Curve

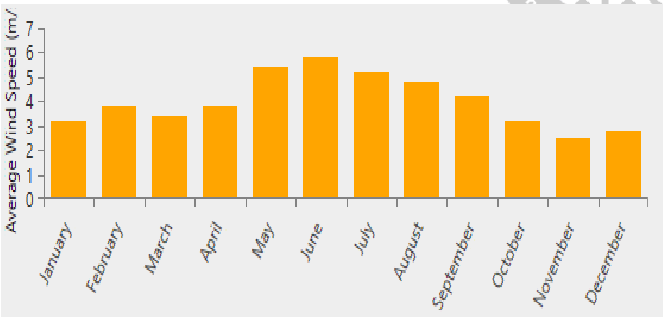

Fig.4 Monthly Average Wind Speed

B. Battery

The battery is Generic 1kWh Lead Acid Battery. Nominal voltage 12V. These batteries are replaced every 5 years. The one battery initial capital cost, replacement coast, and maintenance and operation cost of $300, $300, and $10.

C. Power Converter

A converter is included in order to maintain the flow of energy between the AC and the DC bus. The conventional load is DC type, but generated power from diesel generator is AC type. The size of the converter that is used in this system is 1kW. The initial capital cost and replacement cost and operation maintenance cost are $300, $300 and 0 respectively.

D. Electric Load

Profile: Residential

Load type: AC

The electric load is heavy between 6 to 9 A.M.

E. Photovoltaic Array

Solar PV modules are connected in series parallel. When the sunrays strike the Solar PV panels , it produces electricity . A 1kW solar energy system's installation, and replacement costs are taken approximate as 3000$ and 3000$ respectively. The lifetime of a PV is taken to be 25 years. Monthly solar radiation graph is shown in fig.5.

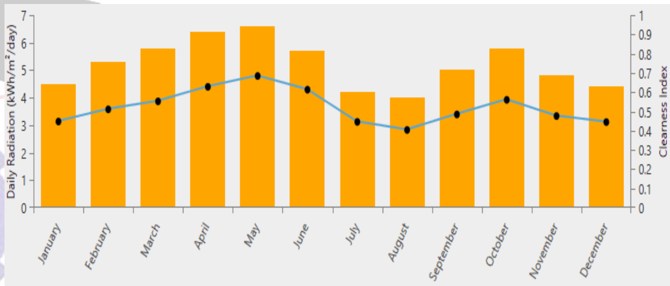

Fig. 5 Monthly Solar Radiation

F. Diesel Generator

The fuel consumption per year is approximate 1400 Litter for 1kW Diesel Generator. The 1 kW diesel generator capital cost , replacement cost, operation-maintenance cost are 500$, 500 $, 0.030$. The lifetime of a diesel generator operating hour is 1500. Fig.6 shows fuel curve of diesel generator.

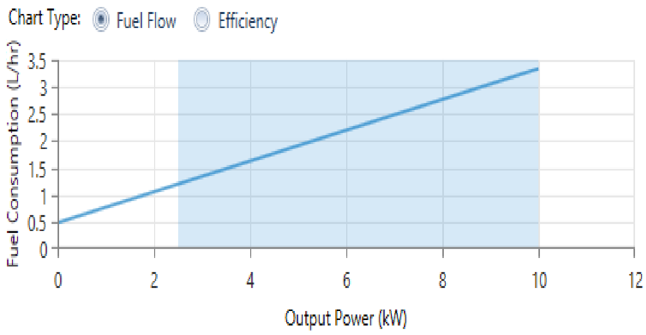

Fig.6 Fuel Flow Curve

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V. SIMULATION RESULT

Fig. 7 Daily Profile of Electric Load.

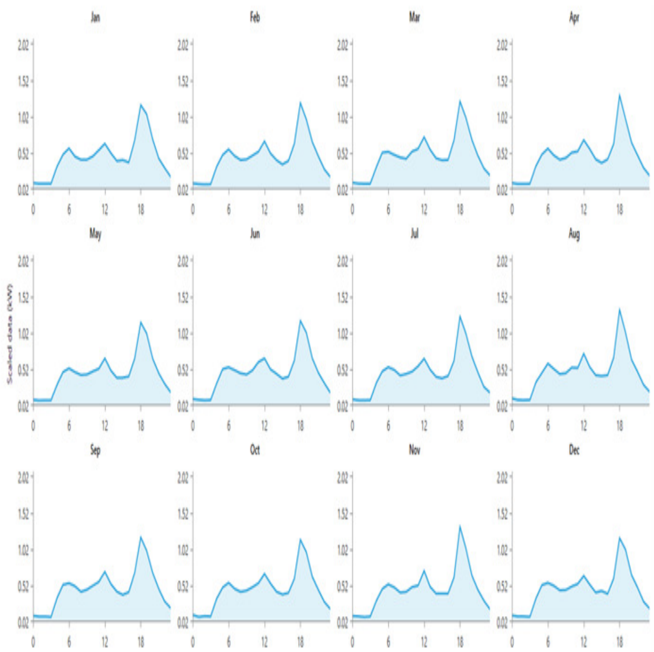

Fig.8 Scaled Data Daily Profile

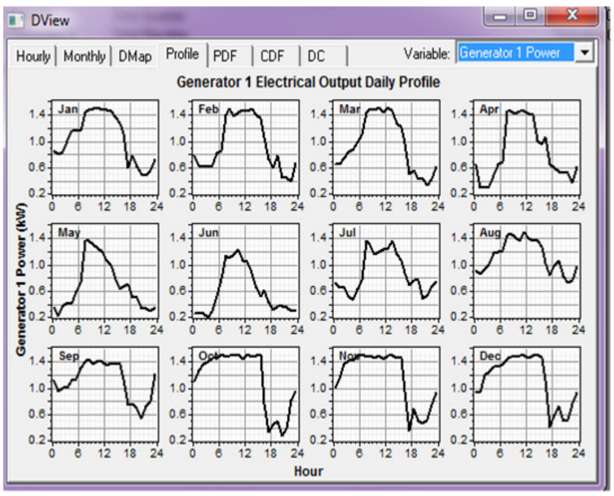

Fig.9 Electrical Output Daily Profile of Generator.

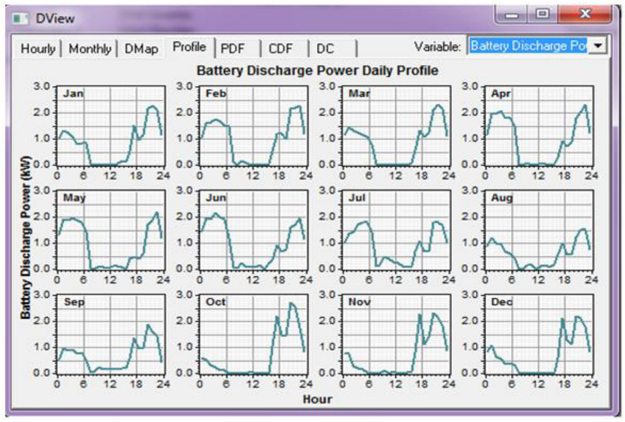

Fig. 10 Battery Discharge Daily Profile.

In simulation results Fig.7 shows daily profile for electric load of 1Kw. Fig.8 shows scaled data daily profile for solar wind hybrid system .Fig.9 shows electrical output daily profile of Generator and fig.10 shows daily profile of battery discharge.

VI. OPTIMIZATION RESULT

HOMER software performs various simulations in order to obtain the optimal hybrid system. Four sensitivity variables are considered in this system and they are wind speed, solar radiation , load and diesel price. The best optimal combination of energy system components are 1kW PV Array, 1 kW diesel generator, 1kW wind turbine.

Table 1 Optimization Results for Wind System

Architecture 1	Architecture 2	Architecture 3	Architecture 4	Architecture 5	Cost/COE ($)	Cost/NPC ($)	Generator Fuel consumption (Liters)
Wind Turbine (1 KW)	Electric Load (1KW)	Generator (10 KW)	Converter (1 KW)	Battery (1KWh)	4.160244	221019.2	8484.051

Table 2 Optimization Results for Solar Panel

Architecture 1	Architecture 2	Architecture 3	Architecture 4	Architecture 5	Cost/COE ($)	Cost/NPC ($)	Generator Fuel consumption (Liters)
Solar Panel (1 KW)	Electric Load (1KW)	Generator (10 KW)	Converter (1 KW)	Battery (1KWh)	3.333978	177122.6	13712.5

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Table 3 Optimization Results for Solar Wind Hybrid System

Architecture 1	Architecture 2	Architecture 3	Architecture 4	Architecture 5	Architecture 6	Cost/COE ($)	Cost/NPC ($)	Generator Fuel consumption (Liters)
Solar Panel (1 KW)	Wind Turbine (1KW)	Electric Load (1KW)	Generator (10 KW)	Converter (1 KW)	Battery (1KWh)	3.323141	10152.52	6083.529

VII. CONCLUSION

This paper presented hybrid solar wind system for a Narhe (Pune) location. System sizing and designing system configuration is presented. In India more than 2 billion people use cell phones . Power is main issue for base station. So, the renewable base hybrid system is most suitable solution. This solution is cost effective and available throughout year.

HOMER software was used to determining optimum hybrid configuration. The comparison made between solar system, wind system and hybrid solar wind system. We are comparing the parameter Generator fuel consumption for solar system, wind system and hybrid solar wind system to decide which system gives the best results. After comparing we get that the generator fuel consumption for wind generator, solar panel and hybrid solar wind hybrid system are 8484.051$, 13712.5$, 6083.529$ respectively. The generator fuel consumption for hybrid solar wind system is less than that of wind system and solar system. So, the hybrid solar wind system is best and it reduces the fuel consumption of diesel generator . 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. 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. It is feasible to use solar wind hybrid power system for higher loading.

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