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AN OPTIMIZATION TECHNIQUE USED FOR ANALYSIS OF A HYBRID SYSTEM ECONOMICS

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Abstract: This work presents the economic feasibility of stand-alone hybrid power system consisting of many renewable as well as conventional energy sources such as PV system, Wind generators, storage battery system and generator system for electrical requirements of the remote locations. It emphasizes the renewable hybrid power system to obtain a reliable autonomous system with the optimization of the components size and the improvement of the capital cost. This hybrid energy system consists of Photovoltaic cell array, wind turbine accompanied with battery and diesel generator for emergency backup considering uncertain availability of these weather dependent sources. As a first step the needed an operational scheme which is organized for measuring the electrical load profile, renewable sources availability, their condition and specifications like solar irradiation, wind rate. Then, the whole hybrid system is simulated in Hybrid Optimization model for Electric Renewable (HOMER) environment. Finally, simulation results are presented for the proposed hybrid energy system for economical aspects.

Keywords: Economic system, Homer, Renewable energy sources, Hybrid power generation system, Micro grid Optimization.

1. INTRODUCTION

The foremost concern for the implementation of any renewable energy technology is its economic feasibility. The high cost of fossil fuel electricity production in small island or developing states due to the high price of oil in the world market coupled with the depleting oil reserves and the importation cost of fossil fuel have stimulated the development of renewable resources for energy production. There is also a growing awareness of the impact of the usage of fossil fuels on global warming. Whereas in most cases it is not possible to eliminate all fossil fuel energy production systems, it is possible to combine traditional technology with renewable energy technologies in order to minimize fossil fuel energy production cost by effective utilization of renewable energy resources for energy production. The trend in global fuel price increase after the 1970 fuel crisis had drawn serious attention of moving in to renewable energy sources. There is large dependence on diesel consumption for electricity generation; therefore this makes the renewable energy a good alternative not only in the cost of diesel but also on the environmental pollution and likely hood of depletion. Solar and Wind energy are among the major source of renewable energy. Hybrid energy system is a combination of different types of renewable energy conversion systems along with conventional in order to fulfill the load demand with more reliability, obtaining reliable and cost effective power solution for the worldwide expansion of telecommunication areas where grid connection presents a very challenging problem. Grids are either not available or their extension can be extremely costly in telecommunication area. Although initial costs are low, powering these sites with generators require significant maintenance, high fuel consumption. Wind speed of the proposed site must be considerably high for easily electrical generation. Wind power with diesel and solar generation has been suggested. Hybrid solar, wind and diesel is very reliable because the diesel acts as a cushion to take care of variation in wind speed and would always maintain an average power equal to the set point. The ability to generate electricity is a building block of modern societies. The utilization of wind turbines to produce electricity has been practiced for over one hundred years. The design idea of optimized PV-Solar and Wind Hybrid Energy System for GSM/CDMA type mobile base station over conventional diesel generator for a particular site in central India (Bhopal)[1]. For this hybrid system ,the meteorological data of Solar Isolation, hourly wind speed, are taken for Bhopal-Central India (Longitude 77o.23'and Latitude 23o.21') and the pattern of load consumption of mobile base station are studied and suitably modeled for optimization of the hybrid energy system using HOMER software. Luiz Carlos Guedes Valente et al. [2] performed an economic analysis on hybrid PV/diesel system and demonstrated that the system has advantages over standalone diesel system. The optimization of hybrid energy systems in the context of minimizing excess energy and cost of energy is addressed by Razak, Sopian and Ali [3]. Kamel and Dahl [4] and Khan and Iqbal [5] used the Hybrid Optimization Model for Electric Renewables (HOMER) software [6] to find optimum sizing and minimizing cost for hybrid power system with specific load demand in standalone applications. Here in this paper we are looking to solve the problem of demand of power and minimized the cost of power generation using a hybrid system with the help of HOMER software. This software has the ability to interconnect the different mode of generating plants and optimize the cost of energy in Rs/h.

2. HOMER SOFTWARE A REVIEW

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 [4]. It has been developed by United State (US) National Renewable Energy Laboratory (NREL) since 1993. It is developed specifically to meet the needs of renewable energy industry's system analysis and optimization. There are three main tasks that can be performed by HOMER: simulation, optimization and sensitivity analysis. In the simulation process, HOMER models a system and determines its technical Feasibility and life cycle. In the optimization process, HOMER performs simulation on different system configurations to come out with the optimal selection. In the sensitivity analysis process, HOMER performs multiple optimizations under a range of inputs to Account for uncertainty in the model inputs. The HOMER Hybrid optimization model for electric renewable software is a powerful tool for designing and analyzing hybrid power systems, which contain a mix of conventional generators, combined heat and power, wind turbines, solar photo voltaic, batteries, fuel cells, hydropower, biomass and other inputs. HOMER helps determine how variable resources such as wind and solar can be optimally integrated into hybrid systems. HOMER determines the economic feasibility of a hybrid energy system optimizes the system design and allows users to really understand how hybrid renewable systems work. HOMER can serve utilities, telecoms, systems integrators, and many other types of project developers- to mitigate the financial risk of their hybrid power projects.

2.1. DESIGN of A Hybrid SYSTEM

This study is concerned with designing a system with minimum total cost of unit of energy to be delivered, to get this various parameters on the system performance needed to be evaluated for optimal design. A sensitivity analysis of the hybrid power systems was performed using HOMER software package developed by the National Renewable Energy Laboratory (NREL), Colorado, and United States was used, to evaluate the influence of different parameters on the system performance (*e.g.*, wind/solar potential of the installation site, fuel price, number of PV panels, number of wind turbines, number of inverters, etc). HOMER is a complete set of software that performs sizing of components for both hybrid and standalone power systems that use renewable sources, and identifies the optimum technical and economical set of components able to comply with the desired demand of electric energy from the system, taking into account of other factors like capital cost, maintenance cost, fuel price and also the environmental constraints like the wind/solar potential of the location for the system. The design of these systems was done based on three considerations viz; technical, economical, and environmental. The technical consideration was during the design specification and component selection, while the economic consideration was during the Homer simulation and also in the selection of the cost effective option, environmental consideration was taken into account when choosing a site for installation.

2.1.1 SIMULATION

HOMER simulates the operation of a system by making energy balance calculations in each time step of the year. For each time step, HOMER compares the electric and thermal demand in that time step to the energy that the system can supply in that time step, and calculates the flows of energy to and from each component of the system. For systems that include batteries or fuel-powered generators, HOMER also decides in each time step how to operate the generators and whether to charge or discharge the batteries. HOMER performs these energy balance calculations for each system configuration that you want to consider. It then determines whether a configuration is feasible, i.e., whether it can meet the electric demand under the conditions that you specify, and estimates the cost of installing and operating the system over the lifetime of the project. The system cost calculations account for costs such as capital, replacement, operation and maintenance, fuel, and interest.

2.1.2 OPTIMIZATION

After simulating all of the possible system configurations, HOMER displays a list of configurations, sorted by net present cost (sometimes called lifecycle cost), that we can use to compare system design options.

2.1.3 SENSITIVITY ANALYSIS

When we define sensitivity variables as inputs, HOMER repeats the optimization process for each sensitivity variable that we specify. For example, if we define wind speed as a sensitivity variable, HOMER will simulate system configurations for the range of wind speeds that we specify.

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2.2. ALGORITHM USED TO OPTIMIZED HOMER

1: Formulate a question that HOMER can help answer:-HOMER can answer a wide range of questions about the design of small power systems. It is useful to have a clear idea of a question that we want HOMER to help answer before we begin working with HOMER.

2: Create a new HOMER file:- A HOMER file contains all of the information about the technology options, component costs and resource availability required to analyze power system designs. The HOMER file also contains the results of any calculations HOMER makes as part of the optimization and sensitivity analysis processes.

3: Build the schematic:- HOMER compares multiple technology options for a power system design. The schematic represents all of the technology options that we want HOMER to consider: it is not a schematic of a particular system's configuration. Schematic is built to give HOMER information about the components to consider answering the question. The schematic may include components that are not in the optimal design.

4: Enter load details: - The load details are entered to the HOMER simulations. The load inputs describe the electric demand that the system must serve. This section describes how to import a sample load file.

5: Enter component details: - The component inputs describe technology options, component costs, the sizes and numbers of each component that HOMER will use for the simulations. This section describes how to enter cost data for diesel generators, wind turbines, and batteries

6: Enter resource details: - The resource inputs describe the availability of solar radiation, wind, hydro and fuel for each hour of the year. For solar, wind, and hydro resources, we can either import data from a properly formatted file, or use HOMER to synthesize hourly data from average monthly values.

7: Inputs check and errors Corrections: - HOMER checks many of the values that we enter in the input windows to see if they make technical sense. If HOMER notices values that do not make sense, it displays warning and error messages on the Main window

8: Examine optimization results: - HOMER simulates system configurations with all of the combinations of components that we specified in the component inputs. HOMER discards from the results all infeasible system configurations, which are those that do not adequately meet the load given either the available resource or constraints that we have specified.

9: Refine the system design: - This section describes how to use the optimization results to improve the system design. For its example, we will see if adding batteries to the system design will reduce the amount of excess energy produced by the system

10: Add sensitivity variables: - In Step Five, you learned that HOMER uses scaled resource data for simulations. This section describes how to enter sensitivity values for both the wind speed scaled annual average and diesel price to perform a sensitivity analysis on these variables. The sensitivity analysis will allow us to explore how variations in average annual wind speed and diesel fuel prices affect the optimal design of the system. Another way to say this is that the analysis will show us the range of average annual wind speeds and diesel prices for which it makes sense to include wind turbines in the system design.

11: Examine sensitivity analysis results: - HOMER displays sensitivity results in graphs and tables. This section describes how to view and interpret the sensitivity results to determine under what conditions a wind/diesel system is more cost-effective than a diesel-only system.

3. HYBRID SYSTEM

Hybrid energy system is a combination of different types of renewable energy conversion systems along with conventional in order to fulfill the load demand with more reliability. This system is combination of solar\ wind, fuel, power conditioning unit and the load. The hybrid system diagram pictured below is used in this paper for study. It has many advantages over the stand alone system such as it is reliability, economic and environmental friendly. In hybrid system, wind power system and PV cells provide DC power. The conversion of DC power is obtained by solar and wind system. A semiconductor-based device (power inverter) is used to convert the DC power in to AC power [8].

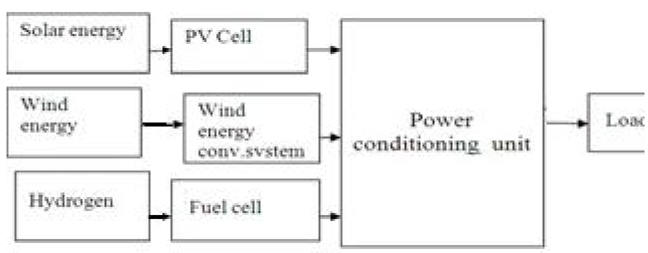

Fig.1. Hybrid system line diagram.

4. SIMULATION MODEL OF HOMER

Simulations were performed by comparing the use of PV/Diesel system and wind/diesel system. It was done based on estimate of 15 years life time. Homer assumes all prices escalate at the same rate; it is not possible to model the escalation of diesel price at different rates. Therefore, calculations are based on current prices and do not reflect the effects of possible further increases of the diesel prices. It is however possible to explore the effects of an escalating diesel price by doing a sensitivity analysis on the diesel price alone. The information presented in the previous section will be used in the homer software to find the optimal hybrid system architecture that can be able to provide electric energy with the cheapest price ($/kWh) [9]. Solar, wind and diesel based hybrid system simulink model has been developed using homer software version 2.81 and the optimization results are obtained. Here one of the telecommunication exchange office of Bhopal has been considered as case system whose details are given in subsequent section.

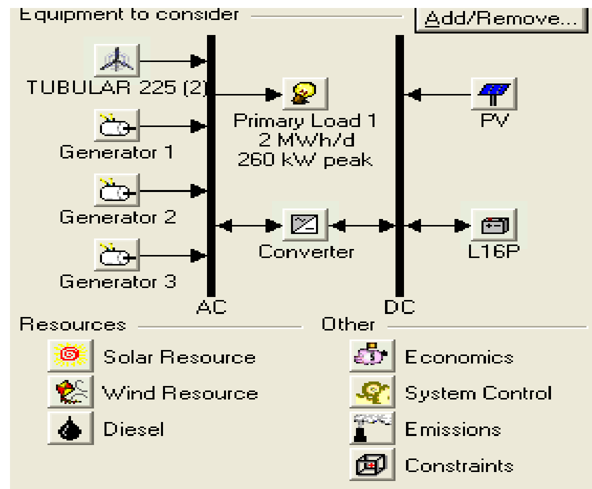

Fig.2 Simulink model on HOMER

4.1. CASE SYSTEM

In present thesis hybrid system has been designed to fulfill the power requirement of the telephone exchange office located in Dist. Bhopal. At this exchange office total 50000 subscribers are connected and the hourly power requirement is shown in Fig. (2). the total average value of load is 1800kW/day.

4.2. LOAD PROFILE

The load profile is based on a hypothetical apartment and the profile is shown in Figure 3. A base load of 1000KW occurs throughout the day and night and small peaks of 1800KW occur in the evening. The total daily load average 3200KW WATT-HOURS PER DAY.

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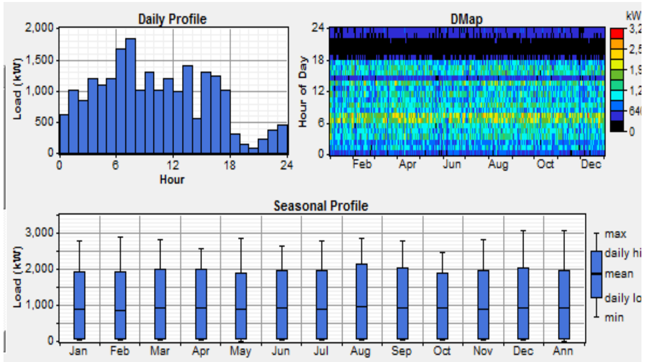

Fig.3.Load Profile

4.3. SOLAR RADIATION & WIND RESOURCE

Fig (4) shows the solar resource profile over one year. The solar resource data for BSNL exchange office of Bhopal MP. Fig (5) shows wind resource profile over a year

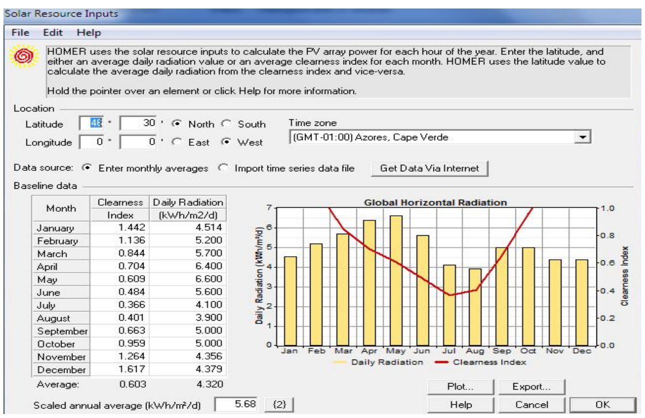

Fig.4. solar Radiation profile

5. RESULT AND DISCUSSION

The model of HOMER is simulated for the data of BSNL exchange for the load demand as shown in fig (1) in this work we used HOMER 2.81. The objective of design of simulation model of hybrid system is to minimize the total generation costs, while satisfying the specified load has been achieved. HOMER optimize in such way to give the idea about the different selecting units such as it gives the idea about how many number of wind turbines, solar arrays, diesel generator and how many battery are used to fulfill the demand. On other words we can say that it also select the optimal generation system according to load demand.

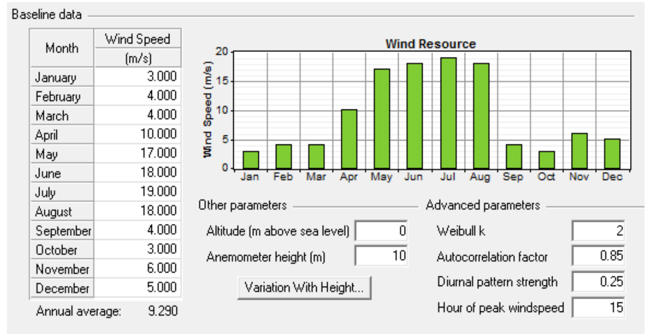

Fig.5 The wind resource profile over a year

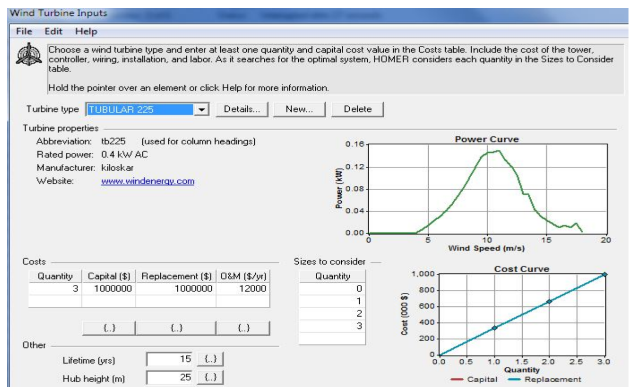

Fig. 6 Wind input data

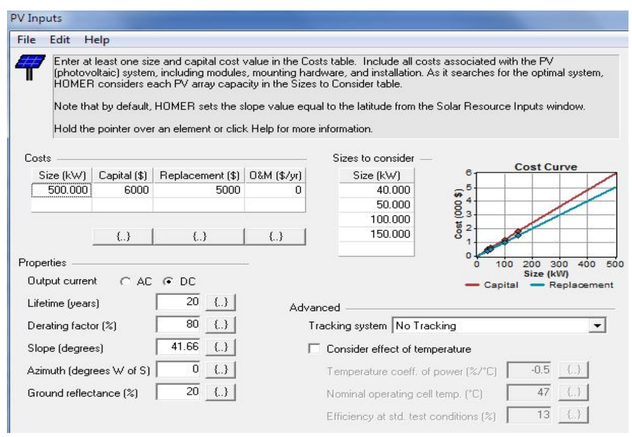

Fig. 7 Solar input data

5.1. SYSTEM PERFORMANCE

Our model was simulated using HOMER, with the objective of minimizing costs, while meeting the specified load. Finding the optimal number of wind turbines and solar arrays to meet the load, as well as the optimal wind turbine height and rotor diameter, was the focus of this study, as well as to test for good complementary characteristics between the wind and solar power systems, and to assess the feasibility of using such a hybrid system to power different applications, such as a station or a village.

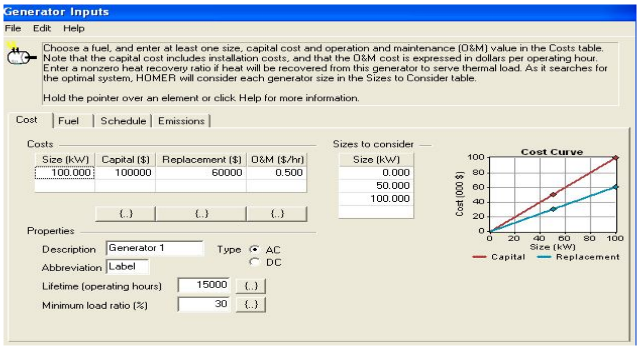

Fig.8 Generators Input

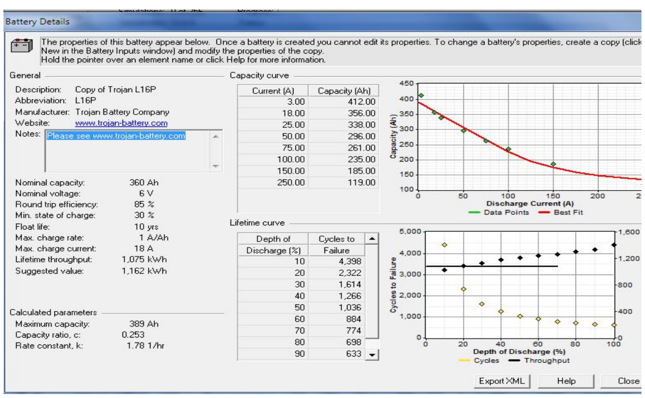

Fig.9 Battery Input data

It is important to note that at first, we tested our model without inputting weather conditions i.e. the wind speeds and solar radiation were considered constant over the year. In this test, with a specified load, our model chose to install wind turbines only, no matter what the load was, without the use of photovoltaic. This is natural, since wind turbines would generate the same amount of electricity at a cheaper price, as solar arrays are quite expensive, so the model would avoid solar arrays to minimize costs. The monthly average Electric production of the system photovoltaic production is 35% and wind is 50% of Total net present cost (NPC), Capital cost and cost of energy for such a system**.** Total net present cost NPC-$3756032, capital cost of energy -$0.401, initial cost-$1253, 200 and operating cost-$195788, respectively for payback time is 15 years.

6. CONCLUSION

In this paper the Hybrid Micro grid system has been successfully optimized for combination of solar, wind and diesel based hybrid system to fulfill the load requirement of telecommunication site in BSNL, Bhopal using HOMER V 2.81. In India more than 2 billion peoples uses cell phone.

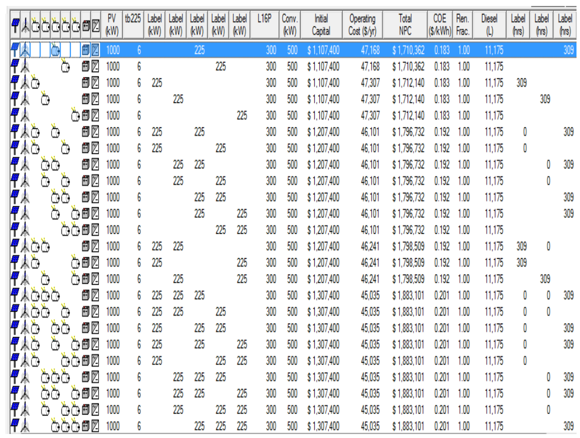

Fig.10 Simulation results of HOMER system

Components	Size	Capital	Replacement	O&M	Lifetime
	(KW)	cost($)	cost($)	Cost($)	(Years)
PV Panel	1000	6000	5000	00	15
Wind turbine	225	1000000 (3 units)	1000000	12000	15
Storage battery	64	500	500	50.00	15
Converters	2000	900	900	0	15
Generators	225	100000	60000	0.050	15

Table: 1:- List of system Components

To provide better network services sell phone operator installed new sell phone base station. Power is main issue for telecom base station, because grid extension is not feasible. The proposed renewable base hybrid system is most viable solution. Alternate power solution are not commonly used in tower telecommunication system today but are actively evaluated for remote and isolated areas over worldwide .With the help of above pre feasibility study the solar and wind hybrid energy system are most viable power solution for cell phone base station in Indian sites over conventional diesel generator .Although the net present cost is high but the running and maintenance cost are low as compared to the diesel generator power solution.

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