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Optimal Design of Hybrid Energy System

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***Abstract*— The use of Renewable energy sources for generation of electrical energy can decrease the costs of system fuel and also can have desirable impact on reliability of system. Therefore a suitable combination between the system reliability indices level and system capital investment costs is required. In this paper a hybrid system consisting of a wind turbine and diesel generator is designed to minimizing the cost of system. For decentralized or remote areas, where grid connection is almost not possible, renewable energy generation system can be a reliable and optimized source of energy. The analysis of the hybrid systems are modeling in the HOMER software package. Here, HOMER is used to examine the most cost effective configurations among a set of systems for electricity requirement.**

***Index Terms*—Renewable energy; HOMER software; Optimization; Hybrid system design.**

INTRODUCTION

Various aspects must be taken into account when working with stand-alone hybrid systems for the generation of electricity. Reliability and cost are two of these aspects; it is possible to confirm that hybrid stand-alone electricity generation systems are usually more reliable and less costly than systems that rely on a single source of energy. In various research papers it has been proven that hybrid renewable electrical systems in off grid applications are economically viable, especially in remote locations. In addition, climate can make one type of hybrid system more profitable than another type. For example, wind diesel hybrid systems (wind–Diesel) are ideal in areas with warm climates. On the other hand, various mathematical models of the elements that make up these systems have been used, as well as various design and simulation models. The complexity of the models of the components of the hybrid systems mainly depends on the type of application. Systems are modeled using software.

NECESSITY OF HYBRID SYSTEM

Hybrid system is considered as one of the most efficient means to access electricity from locally available renewable energy resources where the access to national grid is quite impossible and also not economic. People of several places are out of reach of electricity also because of its geographical landscape and conditions where providing electricity from a centralized power plant through some sorts of transmission lines is not possible. The people residing in such kind of place can be highly benefitted by the means of hybrid system. Also depending upon conventional sources of energy is becoming harder day by day due to its rising prices and limited availability. Thus developing countries burdened by the high costs of imported fuel can benefit from small, sustainable renewable energy system that use a combination of a solar, wind and micro-hydro technologies to electrify rural, off-grids towns and villages.

HYBRID RENEWABLE ENERGY SYSTEM

Among the renewable energy sources wind energy have been utilized with diesel engine in this study. The hybrid generation system consists of an electrical load, renewable energy sources and other system components such as wind turbines, diesel generator and converter. Fig.1 shows the hybrid energy renewable system.

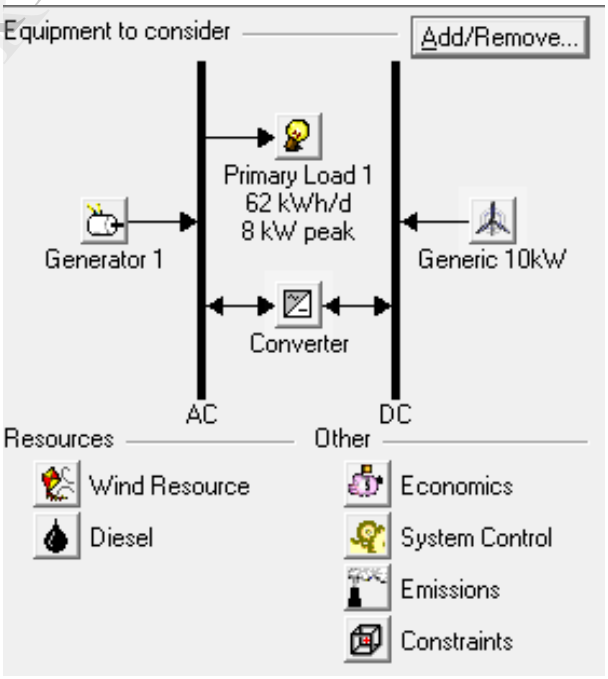

Fig 1: Hybrid Renewable Energy System

In the present work, the selection and sizing of components of hybrid power system has been done using HOMER software. HOMER is general purpose hybrid system design software that facilitates design of electric power systems for stand-alone applications.

Electric Load

A group of households has been considered of a particular area. The annual peak load to 7.9Kw and primary load to 60 KWh/day. Fig. 2 shows load profile on a day. The proposed hybrid power system is designed to ensure the electric supply of a household with an average energy consumption of 60 K Wh/d and peak load of 7.9K W.

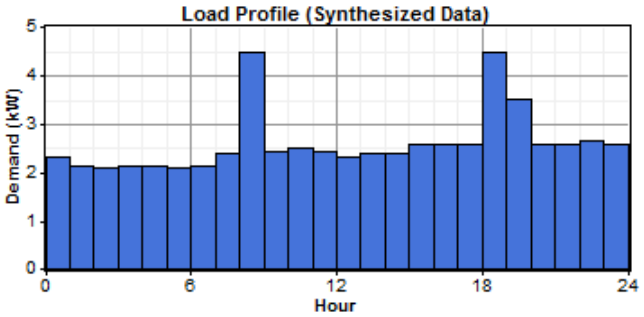

Fig 2: Load Profile

The proposed hybrid power system is designed to ensure the electric supply of a household with an average energy consumption of 60 K Wh/d and peak load of 7.9K W.

Wind Energy

Wind speed also varies seasonally. Average wind speed of the respective area is 4.039 m/s .These data were collected. Figure 4.3 shows the monthly wind speed variation. The Weibull value K value is a measurement of Distribution of wind speed over the year. The value of K is Taken 1.97. The autocorrelation factor: This factor measures the Randomness of the wind. Higher values indicate that the wind speed in 1 hour tends to depend strongly on the wind speed in the previous hour. Lower values mean that the wind speed tends to fluctuate in a more random fashion from hour to hour. The autocorrelation factor value is taken as 0.85.

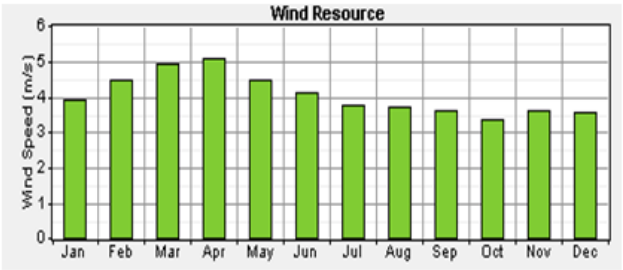

Fig3: Monthly Wind Speed Variation

Diesel Generators

In the proposed system diesel generator is used. Diesel generators operate in parallel with the wind turbine to increase the maintenance flexibility, efficiency and distribute the electric load more optimally. The cost of a diesel generator depends on its size. The diesel generators utilized are of 10kW for a capacity range of 5Kw to 45Kw, the slope and the intercept are 0.33 l/h/Kw and 0.05 l/h/Kw respectively. A diesel generator of 10 Kw rated power with technical and economic parameters inTable1.

TABLE 1 SPECIFICATIONS OF DIESEL GENERATORS

Parameter	Unit	Value
Capital cost	$/KW	10000
Replacement	$/KW	8000
Operation and Maintenance cost	$/h	20
Operational life time	Hour	15000
Minimum load ratio	Percent	10

Wind Turbine

Starting wind speed is considered as 3 m/s in this study. Cut off wind speed is 14 m/s. Technical parameters and cost assumptions are stated in Table 2.

TABLE 2
SPECIFICATIONS OF WIND TURBINE

Parameter	Unit	Value
Rated Power	KW	10
Starting wind speed	m/s	1
Hub height	m/s	18.288
Cut-off wind speed	m/s	14
Capital cost	$/KW	32000
Replacement	$/KW	29000
Operation and maintenance	$/year/turbine	400
Life time	Year	30

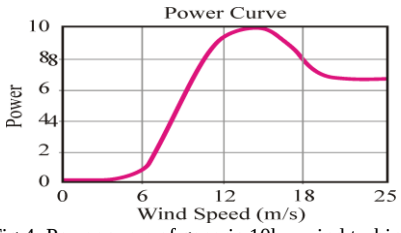

Fig 4: Power curve of generic 10kw wind turbine

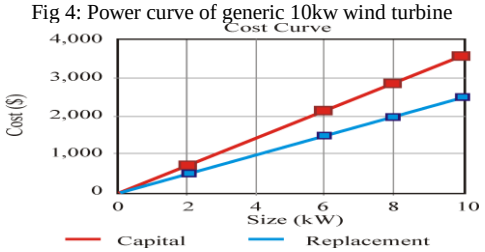

Fig 5: Cost curve of converters

Cost Optimization

The aim of this study is to achieve a stand-alone hybrid generation system, which should be appropriately designed in terms of economic, reliability, and environ-mental measures subject to physical and operational constraints/strategies. The system cost is defined as sum of WG cost (CWG), convertor cost (CCONV)

CSYSTEM = CWG + CCONV

The cost for each element should be deducted:

$$Ci = Ni \times [C\,Costi + R\,Costi \times Ki + OM\,Costi] \quad (4.1)$$

i = WG

Where Ni is the number/size of the system component, CCosti is the capital cost, RCosti is the replacement cost, Ki is the number of replacement, and OMCosti is operation and maintenance cost through the system operation.

Results and Discussion

Simulation results which include each component size, each system configuration's costs and total net present cost of the optimal combination are show in Fig. 6 with selected diesel price of $.4/Liter and wind turbine height of 35-m. and wind speed 4.5 m/s. In the simulation, wind turbine output, environmental effects are analyzed.

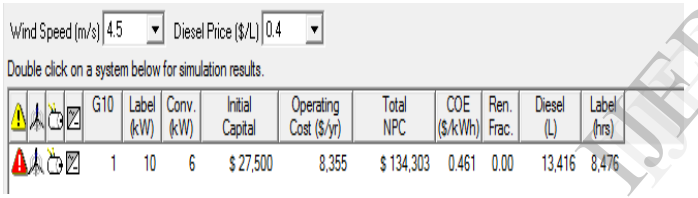

Fig 6: HOMER categorized simulations results

Emission Analysis

Energy generation from renewable energy sources reduces the emission of SO2 and NOx to the atmosphere. Wind-diesel hybrid system with reduces gas emission by a significant amount due to reduced fuel consumption. The reduction in gas emission is determined using HOMER software.

Table 3 Ammount Of Emmission

Pollutant	Emissions (kg/yr)
Carbon dioxide	35,329
Carbon monoxide	87.2
Unburned hydocarbons	9.66
Particulate Matter	6.57
Sulfur dioxide	70.9
Nitrogen oxides	778

CONCLUSION

Remote areas cannot be connected to the grid as they are discrete from main land. Due to high cost of diesel, only diesel-based power generation is not economically feasible. For this, wind-diesel hybrid can be a perfect solution for electrification of the households.

The results of HOMER simulation and modeling shows that optimization emissions and cost of wind turbine, battery and converter us considered as a whole, Wind-diesel hybrid system is far better than a system with only diesel generator due to high cost of diesel. This system is able to developing and acting in remote areas that the lighting loads have the most contribution in peak load.

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