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Energy Audit and Economic Analysis of Photovoltaic (PV) and Generator based Hybrid System using Homer Software

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ABSTRACT

Designing an optimized hybrid power system model is considered to be one of the most challenging areas in Electrical Engineering stream. The hybrid model which is developed should be of cost effective and environmental friendly. To accomplish this task, it is of utmost importance to carry out optimization process with the help of dedicated software. Hence, in order to model a micro power optimized model, it is preferable to use Homer software which basically provides a platform to develop an eco friendly model. This paper presents a case study of grid-connected hybrid system which was exclusively developed in Homer environment and simulation results are shown. Focus is given on cost analysis and ensuring emission level control of the complete hybrid system.

Key words: Optimization process, Hybrid power system, Homer software, Emission level control, Grid-connected

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INTRODUCTION

HOMER is an optimization software which mainly simplifies the task of evaluating designs of both off-grid and grid-connected photovoltaic (PV) power systems for a variety of renewable energy applications [9]. In this software, the inputs should be specified clearly regarding the configuration of the system, technology options that have to be used and their cost particulars. HOMER's optimization and sensitivity analysis algorithm makes it easier to evaluate many possible system configurations [1].

HOMER software performs the energy balance calculations for every possible system configuration. It particularly determines whether a configuration is feasible, i.e., whether it can meet the electric demand under the conditions that are specified, and estimates both the installing and operating costs of the system over the lifetime of the project which is to be designed. The system cost calculations mainly account for costs such as capital, replacement, operation and maintenance, fuel, and interest [11]. Several research works explained in [2-8] have already been attempted to enhance the performance of hybrid system and developed the optimized model but given less preference to emission control aspect. This paper illustrates the impact of emissions on the environment and measures to reduce them through a case study.

SYSTEM ARCHITECTURE DESIGN

A system which includes a generator, PV system, primary load and converter system along with grid is considered as shown in Fig.1. The complete system is designed and modeled in homer environment. Fig.1 represents the hybrid model and optimization method is applied to this model. By optimizing this model, it becomes convenient to check its feasibility options in reality [10].

The model shown in Fig.1 represents that, the load demand is being met by both PV source and generator. A Power processing unit i.e. a converter is also used in the system to facilitate the conversion process from AC to DC and vice versa. It is noted from Fig. 1 that, the generator is connected to AC bus and PV source is connected to DC bus. The required data has to be specified in the fields of solar resource, diesel, economics, system control, emissions, and constraints. Depending on the inputs given, the homer software produces the optimized pictorial models.

Inputs Given to the System

The Fig.2 shows the primary load input that has to be given to the system. From Fig. 2, it can be noted that, on hourly basis the load requirement is specified to the system. In other words, Fig. 2 represents the load profile data.

The load might be either AC or DC. There is a need to give PV input values especially the rating of PV, the total initial capital cost, maintenance cost and replacement cost which is depicted in Fig.3. Along with PV rating details, it is necessary to give solar radiation data on daily or monthly basis which is represented in Fig. 4(a) and Fig. 4(b). The software by default generates the radiation pattern as shown in Fig. 4(c). Also, the converter rating values are to be mentioned as shown in Fig. 5.It is important to enter the rating details of generator as shown in Fig. 6 respectively.

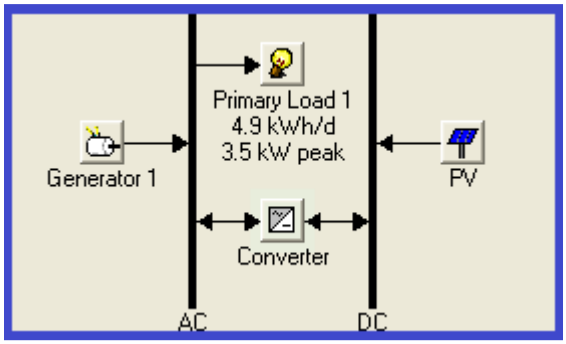


Fig. 1 Hybrid model to be optimized

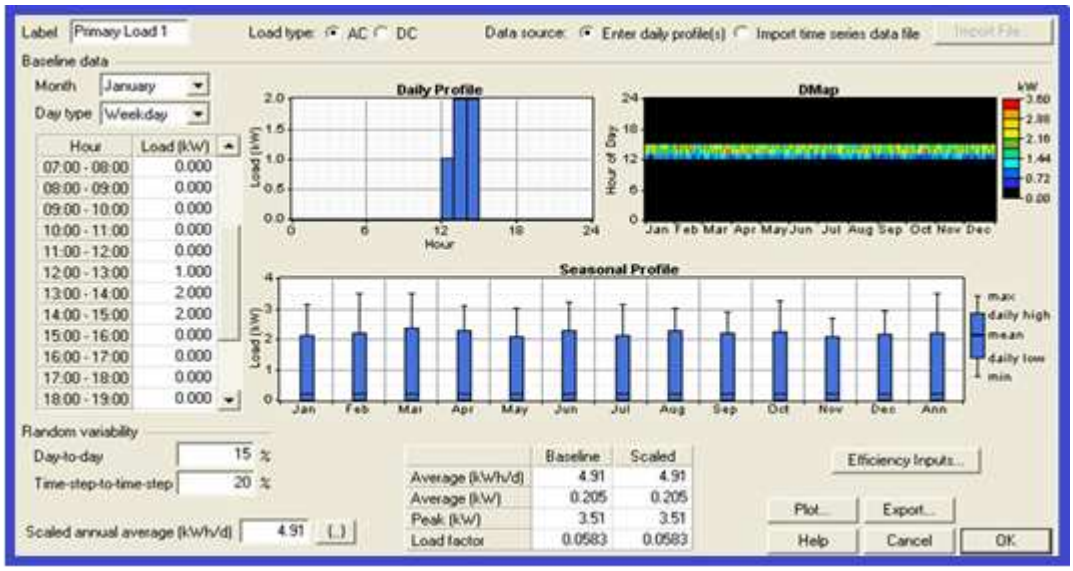


Fig. 2 Primary load inputs

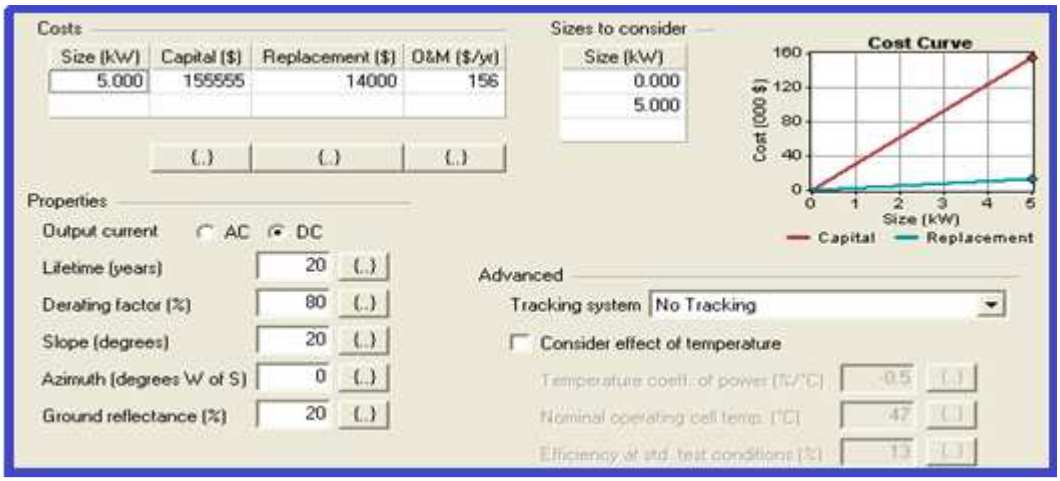
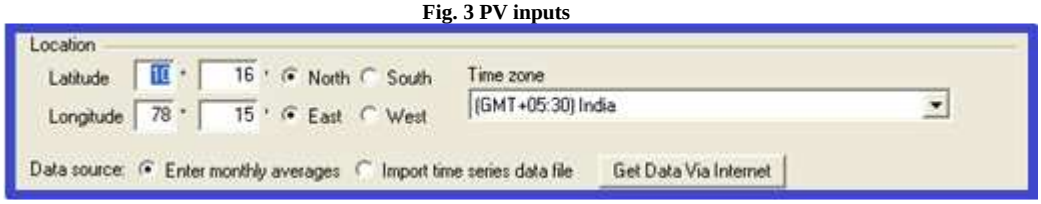
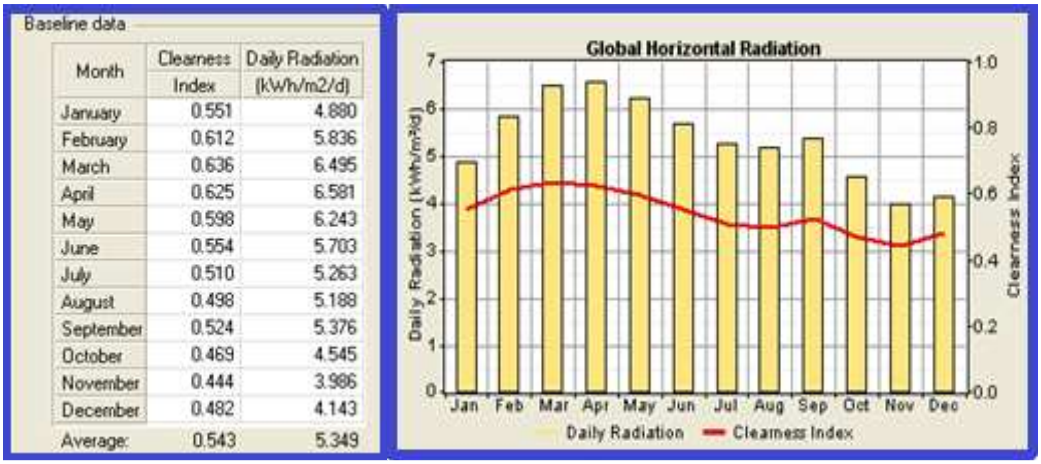


Fig. 3 PV inputs



(a)



(b) (c)

Fig. 4 (a) Solar radiation location input (b) Monthly radiation data (c) Solar resource inputs

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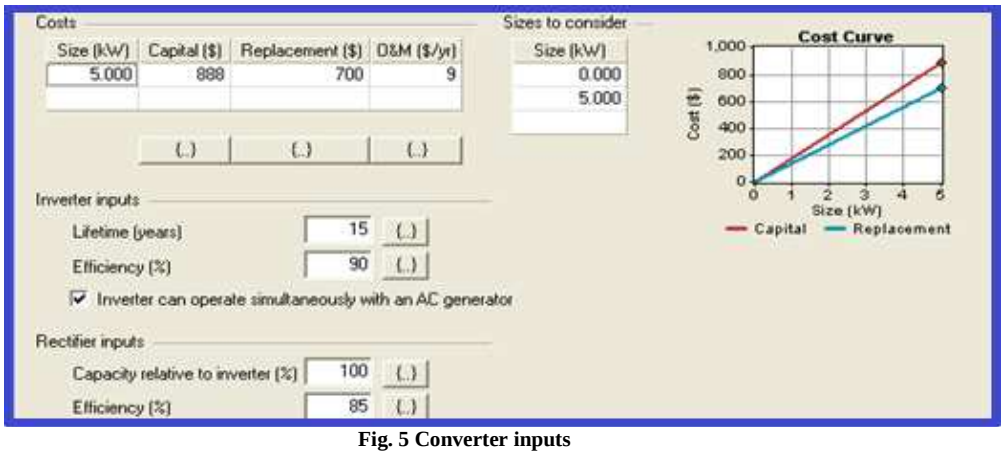

Fig. 5 Converter inputs

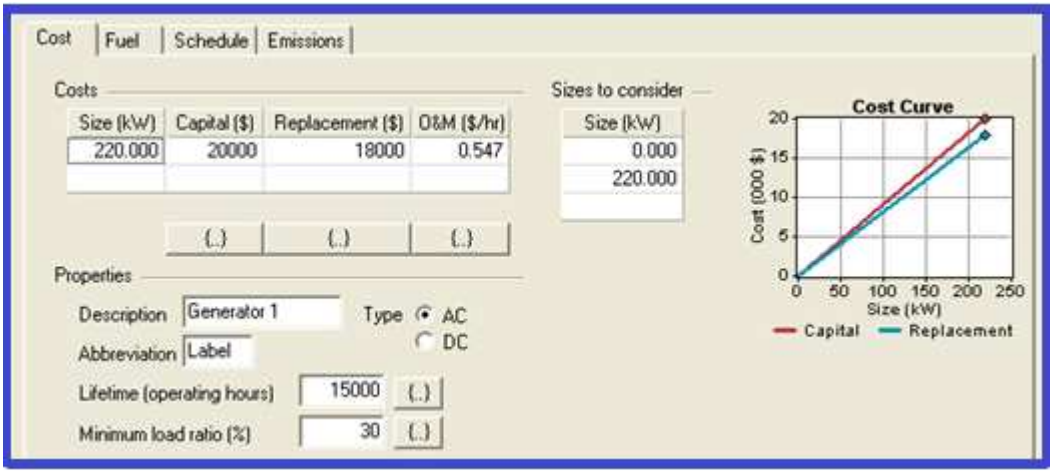

Fig. 6 Generator rating input

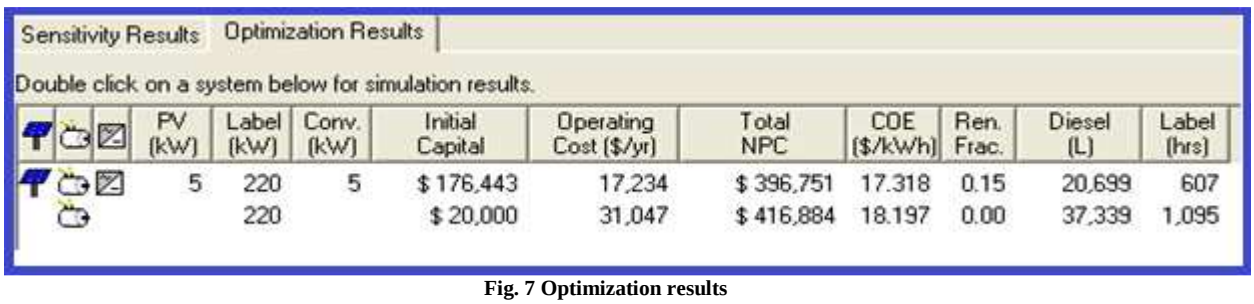

Fig. 7 Optimization results

The input values are given considering the size (kW), capital cost, replacement cost and maintenance cost for PV, Generator and converter systems. Also, the primary load is given considering '3' hour load requirement. Then summary of optimized model is generated by the software as shown in the Fig. 7. In Fig. 7, it can be seen that, there are two cases, namely: in first case the number of energy sources are '2' along with converter. In second case, the number of energy source is only '1' i.e. generator. In Fig. 8, the total expenditure details have been obtained through simulation.

Thus, a system has been modeled with a combination of PV system, generator and converter system and with the generator alone.

SIMULATION RESULTS

Cost Summary Details

Fig. 9 list outs mainly the summary of the cost of system architecture. Fig. 10 lists out the monthly electricity production from PV and generator. Even though the initial investment cost of generator is low, it is convenient to invest capital on PV source because the effluent emission from the PV source is zero and ensures reduction in environmental pollution. Fig. 11 represents the emission levels from complete system consisting of PV, Generator and converter system. Fig. 12 shows emissions exclusively from generator only.

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
PV	155,555	4,365	1,994	0	-2,446	159,468
Generator 1	20,000	4,265	4,244	211,678	-4,145	236,042
Converter	888	292	115	0	-54	1,241
System	176,443	8,922	6,354	211,678	-6,646	396,751

Fig. 8 Total cost expenditure

Fig. 9 System architecture cost summary

Monthly Average Electricity Production

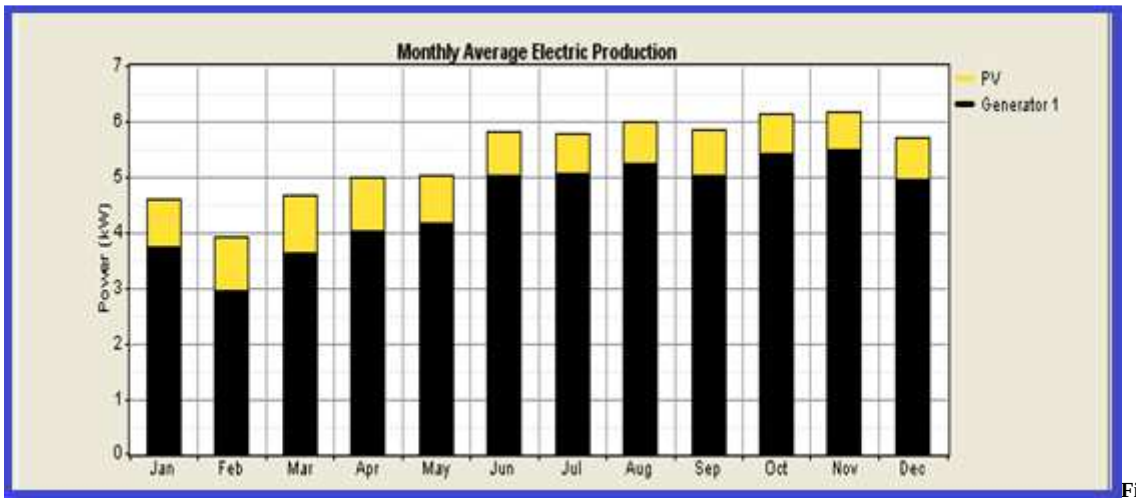

Fig. 10 Electric production details of PV and Generator systems

Pollutant	Emissions (kg/yr)
Carbon dioxide	54,506
Carbon monoxide	135
Unburned hydrocarbons	14.9
Particulate matter	10.1
Sulfur dioxide	109
Nitrogen oxides	1,201

Fig. 11 Emission level of '3' system

Pollutant	Emissions (kg/yr)
Carbon dioxide	98,327
Carbon monoxide	243
Unburned hydrocarbons	26.9
Particulate matter	18.3
Sulfur dioxide	197
Nitrogen oxides	2,166

Fig. 12 Emissions evolved only from Generator

It is observed from the simulation results that, the emission level when PV, converter system and generator combined is low when compared to the emission level when generator alone is considered. It is essential to look for either PV based or Fuel cell based or wind energy based hybrid systems to meet the load demand and also to ensure environmental protection.

CONCLUSION

A case study to mitigate the problem of optimizing a hybrid model which consisting of PV, Generator and Converter is studied and explained. The simulation results clearly shows that, there is a need for developing an eco-friendly hybrid system i.e. instead of generator, it is better to use either a wind based (or) Fuel cell based system further in order to reduce the emission of gases considerably. The procedure for obtaining an optimized hybrid model is explained keeping in view the economic prospects and environmental issues. This paper discussed about the PV based hybrid system and illustrated its economic aspects when combined PV source with diesel based generator.

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