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Optimization in design of hybrid electric power network using HOMER

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ABSTRACT

This research work proposes to refine the hybrid electrical power network to supply a single residence's electrical load located in Coimbatore, Tamilnadu. The load shape of the household is considered by the pattern of energy usage used and supplied for different electrical uses by the PV/Wind/Diesel Generator (DG) set. The simulation and optimization of the scheme is carried out by the Hybrid Optimization System for Electric Renewable (HOMER) model from the National Renewable Energy Laboratory (NREL). The various analyses were discussed like Net Present Value (NPV), Energy Expense, Energy Output, Usage, Excess Energy generated by individual components of the system and the pollution produced.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Advances in Materials Research – 2019.

1. Introduction

In our country, due to huge numbers of people, new industries, government policies and commercial sector and grid, the adequate energy demand on the market cannot be supplied. India has a vast area, and there are so many remote villages and districts that it needs a stand-alone power generation network to meet the end user's energy needs or such isolated places in their entirety.

More sufferers due to long distance power transmission, high grid construction costs and traditional power generation greenhouse gas emissions are the main problem associated with grid electrical supply. The 100 percent electricity supply can only be achieved by the use of standalone power generation. Various literature reviews [1–5] related to HOMER optimization was studied.

A comparative economic analysis between the conventional and the optimized system (PV-wind system) employing HOMER software package (HOMER, 2005) has been performed. HOMER is general purpose hybrid system design software that facilitates design of electric power systems for stand-alone applications. HOMER is a simplified optimization model, which performs hundreds or thousands of hourly simulations over and over (to ensure best possible matching between supply and demand) in order to design the optimum system. It uses life cycle cost to rank order these systems (NREL).

2. Methodology

The concern begins with the electrical or thermal load requirement for individuals, societies, organizations, and industries as necessary. After that the available resources on a specific terrain are considered. Asset analysis helps in determining the selection of components for the hybrid energy network [6,7]. The part size can be adjusted by using different simulation methods for the hybrid energy system or by using the optimization algorithm. HOMER Pro is used as an optimization tool for this analysis. Workflow is shown in Fig. 1.

3. Load profile

The single house electric load pattern located in Coimbatore, India was used for this work. The average house load is determined by the total number of house-fitted electrical appliances shows in Fig. 2. The residential house is composed of seven rooms in each room with two 25w lamps, one CFL-18w and one fan-45w, one LED TV-35w, one desk top panel with LED display, and one

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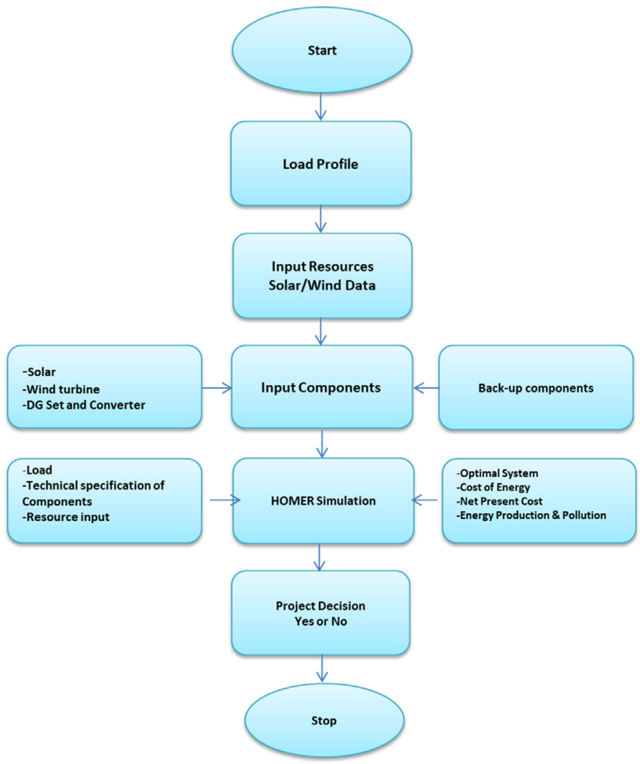

Fig. 1. Flow of work.

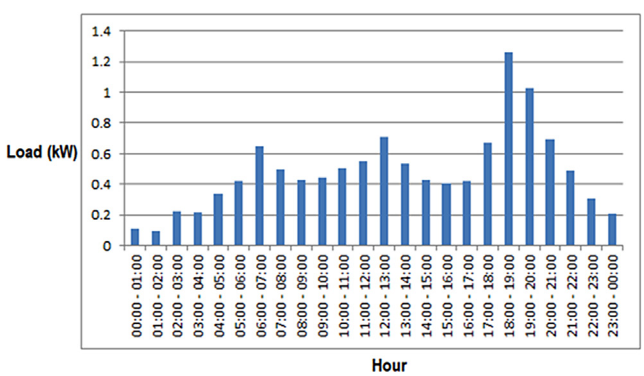

Fig. 2. Daily Load profile.

refrigerator. Every day two night safety lamps are operating for the duration of night time [8,9].

The load pattern is predicted by assuming appliances working at a time for the entire day. The maximum load of the house is multiplied by the demand factor for a house given in the International norm for accurate load estimation.

4. Proposed model

For a specific topography, the grouping of 1 or more traditional and non-conventional power sources is used to eliminate the discontinuous existence of renewable energy sources and to maximize power generation by attaching all available renewable energy resources such as Photovoltaic, Wind turbine system and biomass [10–12]. The hybrid device proposed model consists of PV, Wind turbine, DG Collection, Converter and Battery is shown in Fig. 3.

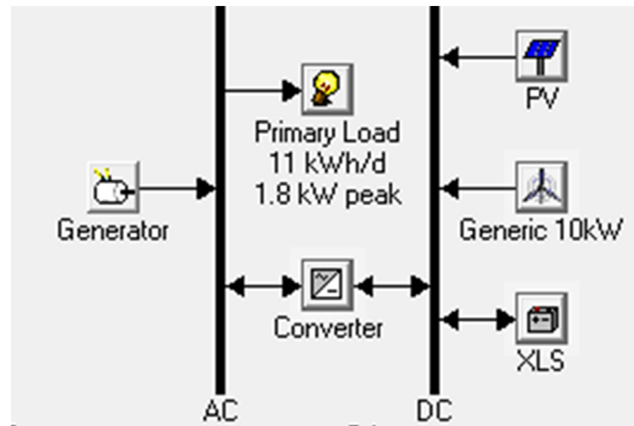

Fig. 3. Proposed Model.

Table 1
Sizing of Components.

Components	Sizes to consider
Honda – DG Set (2.6 kW)	0.000, 2.600 (kW)
Kondas – Converter (1 kW)	0.000, 1.000, 2.000, 3.000, 4.000 (kW)
PV (1 kW)	0.000, 1.000, 2.000, 3.000, 4.000, 5.000 (kW)
Genric – Wind Turbine (10 kW)	1,2 (Nos.)
Exide – Batery	0, 6, 12, 18, 24, 32, 40 (Nos.)

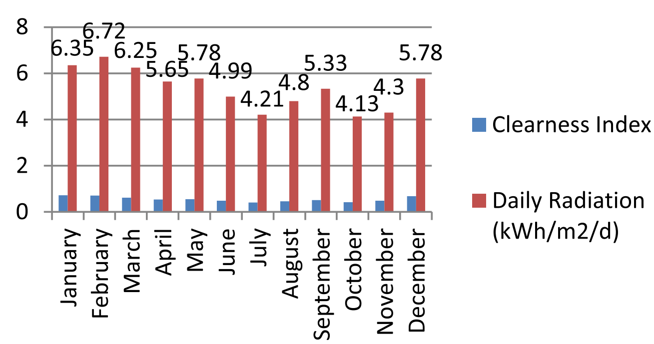

Fig. 4. Solar Data.

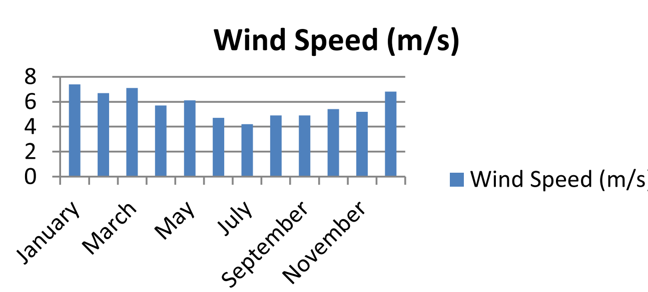

Fig. 5. Wind Data.

5. Components and input parameter

The best size of each part used in configuration of the hybrid energy system (HES) is the key constraint in hybrid energy system design [13,14,15]. Sizing of various components used in a proposed

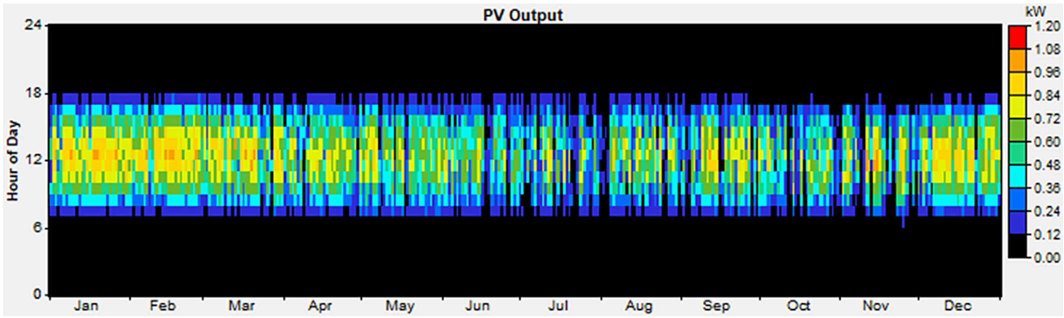

Fig. 6. Photovoltaic Output.

Table 2
System Parameters.

Components	Capital Cost	O&M	Replacement	Life Time
Honda – DG Set (2.6 kW)	72,000	3,000	72,000	20,000 Hrs
Kondas – Converter (1 kW)	60,000	0	60,000	15 Years
PV (1 kW)	64,000	0	4,80,000	25 Years
G-10-Genric – Wind Turbine (10 kW)	3,12,000	8,000	3,12,000	20
XLS-Exide – Batery	17,600	320	17,600	10

Table 3
Optimized results from HOMER (Best 3).

Optimal Configuration	PV (kW)	G10 (Nos.)	Gen (kW)	XLS (Nos.)	Con (kW)	Initial Capital	Operating Cost	Total NPC	Renewable Fraction
1	1	–	2.6	12	1	9,03,200	1,20,960	21,94,640	0.34
2	1	1	2.6	12	1	12,15,200	92,960	22,07,600	0.64
3	–	1	2.6	12	2	7,15,200	1,46,160	22,75,680	0.34

Table 4
Cost Analysis.

Optimal Configuration	PV (kW)	G10 (Nos.)	DG Set (kW)	XLS (Nos.)	Con (kW)	Initial Capital	Operating Cost	Total NPC	Cost of Energy (CoE)
1 – PV + DG Set	1	–	2.6	12	1	9,03,200	1,20,960	21,94,640	51.20
2 – PV + WT + DG Set	1	1	2.6	12	1	12,15,200	92,960	22,07,600	51.52
3 – WT + DG Set	–	1	2.6	12	2	7,15,200	1,46,160	22,75,680	53.12

system tabulated in Table 1. The total PV generated output is shown in Fig. 6.

The part can be optimized as the feature of different parameters such as form of supplied load, NPV, energy cost, energy fraction, pollution factors, financial constancy, etc. Figs. 4 and 5 shows the solar radiation, clearness and wind data of the location. The data were obtained from Synergy Environmental Engineers website.

The proposed design consists of Solar PV, Wind turbine, DG Set, Converter and Battery. The proposed system parameter is shown in Table 1.

6. Optimization results (cost analysis)

The main key factor of hybrid energy system is design of optimum size of every components used. The each component is configured with function of different specification such as type of load, NPV, energy cost, energy fraction, pollution, investment, etc. Homer model is used in this work. This Homer model takes as input technical and economical parameters of PV, wind turbine, converter, battery, solar and wind resources. After successful sim-

Table 5
Simulation Results.

Optimal Configuration	Electrical Production (kWh/Yr)			Total	Total (%)	Electrical Consumption (kWh/Yr)	Excess Electricity (kWh/Yr)
	PV (kW)	G10 (Nos.)	DG Set (kW)				
1 – PV + DG Set	1676	–	3226	4902	100	4015	0.000696
2 – PV + WT + DG Set	1676	1904	2038	6518	100	4015	829
3 – WT + DG Set	–	1904	3766	5680	100	4015	481

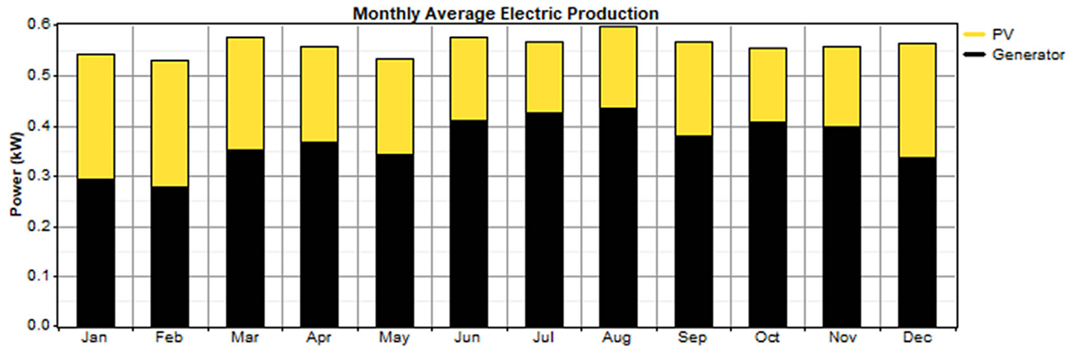

Fig. 7. Monthly average electric production of Optimal Configuration 1.

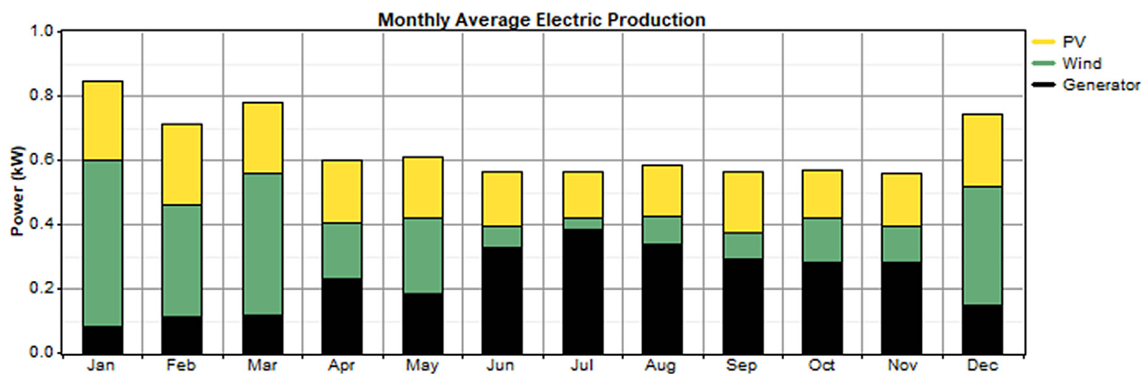

Fig. 8. Monthly average electric production of Optimal Configuration 2.

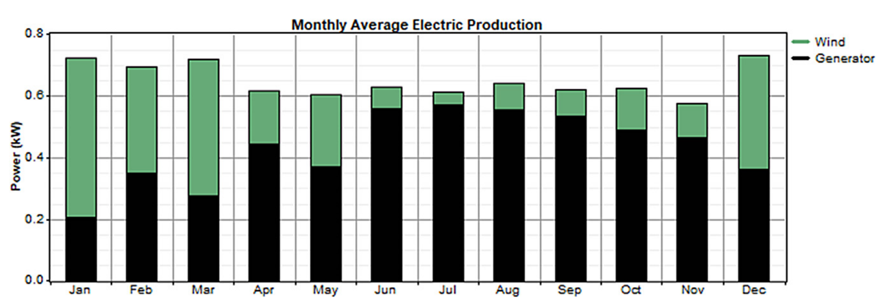

Fig. 9. Monthly average electric production of Optimal Configuration 3.

ulation it gives optimum size of HES components. Optimized results obtained by Homer are shown in Table 2 (Table 3).

Results of HOMER simulation include energy output; consumption and excess energy output of individual components linked to the hybrid device as well as pollutants are shown in Table 4.

Table 6
Pollutant Details.

Optimal Configuration/Pollutant	1	2	3
	Emissions (kg/yr)		
Carbon dioxide	4732	3003	4960
Carbon monoxide	11.7	7.41	12.2
Unburned hydrocarbons	1.29	0.821	1.36
Particulate matter	0.881	0.559	0.923
Sulfur dioxide	9.5	6.03	9.96
Nitrogen oxides	104	66.1	109

7. Simulation results

The total output, electricity consumption by all sources in the system, and the fraction of the total electrical output generated by renewable sources are defined in Table 5. Excess electricity represents the cumulative amount of energy that happened during the year.

Detailed simulation output of Monthly average electric production of best three Optimal Configurations is shown in Figs. 7–9. Table 6 lists in-depth details of pollutants produced by 3 optimal configurations. Comparatively optimal solution 2 is produced least pollution.

8. Conclusions

This paper reflects the study of a possible Hybrid framework, taking into account the various sensitivity parameters with the help of HOMER. The proposed hybrid model performs an optimisation of these sensitivity parameters. The proposed model was technically analysed for system components, component sizing, optimized system, energy production, energy consumption and Excess Energy Production. The basic parameters for optimisation are NPC and COE. Results of the simulation show that the lowest NPC and initial CoE is 51.20 INR/kWh. The results show the initial cost of the overall system is high. The emissions are little bit high in the optimized system. Grid costs are not taken into account here, because our proposed model is a stand-alone system.

CRediT authorship contribution statement

K. Balachander: Conceptualization. **G. Suresh Kumaar:** Methodology. **M. Mathankumar:** . **A. Manjunathan:** . **S. Chinnapparaj:** Validation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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