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Optimal design of smart grid renewable energy system using Homer programme

Smart grid is a network created through information technology, communication technology and electrical power systems. It is simply a "smarter" power grid which ensures a two-way communication between user and the power supplier. This work proposes a smart microgrid design hybrid renewable energy system based on solar, grid and wind energy resources. The optimization has been performed using homer software programme to get the best and optimal operation system. Hybrid system combines several energy systems together which offer increased energy reliability and security, and carry a large economic opportunity in terms of cost saving. A typical microgrid system would also include intelligent management that interfaces with the equipment via wired or wireless communication protocols. In the present work the optimization model has been developed for the optimal operation of the system. The modelled system collects meteorological and load data from a town. The optimal hybrid system design is realized by satisfying the load demand, nonlinear seasonal variations and equipment constraints. The main focus of the system is on operation of smart microgrids to maximize usage of green energy, reduction of environmental emissions, decrement of levelized cost of electricity and intelligent management of overall system.

Keywords: Homer software, smart grids, india, renewable resources, energy access, optimization model.

1.0 Introduction

Observing the ever-increasing population of India, the demand for energy is expected to increase significantly. This growing energy demand will result in installing many new power stations, which run on fossil fuels and the burden on the fossil fuels will increase to meet the energy requirements [1-3]. India has centralized energy infrastructure where bulk power is generated at a centralized station and transmitted to larger distances and eventually distributed among the consumers. A smart grid has a characteristic of two-way flow of electric energy and it can monitor and control the devices from a remote utility location [4-5]. Moreover, the smart grid uses renewable energy resources so the burden on fossil fuels decreases and will also help in decreasing the pollution level. Renewable energy resources include solar, wind, hydro, batteries etc. and India has seen a tremendous growth in wind and solar energy production with a wind power capacity of 24.7 GW and solar power capacity of 4.68 GW [6]. Hybrid plants are those plants which produce electric energy from one or more renewable energy resources and they are very suitable in tropical countries like India hence there is a need to enlighten our work in this field. Solar and wind can be considered as main sources of renewable energy but due to their variable nature they cannot supply the load continuously [7], also as the load demands are always changing, there is a need for additional battery storage and grid supply for providing continuous power supply to the load.

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2.0 Objectives of the proposed model

This paper mainly focuses on a photovoltaic, wind, battery and grid based system. The proposed RETs (Resolution Enhancement Techniques) optimization model, which is a hybrid optimization model for electric renewable (Homer) software and explains all elements of the proposed system.

2.1 Renewable Energy Resources

The solar energy resources data was taken from the official website of NASA surface meteorology and solar energy website as is shown in Fig.1. Homer calculates the monthly solar radiation based on the average solar radiation figure shows the monthly annual average solar radiation and clearness index. Annual average solar radiation reading is of 5.85 kWh/m²/day.

Wind speed obtained at 50m above the surface of earth is shown in Fig.2, ranging from 5.67 to 3.52 m/s, June being the highest wind speed month.

2.2 System Load Profile

The area considered is one of the Indian Societies. Society in India is taken into consideration and the "community" load

Fig.1: Monthly average solar radiation data and clearness index

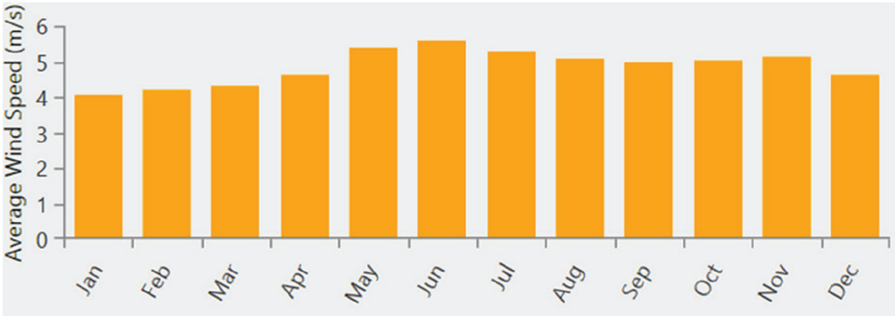


Fig.2: Monthly average wind speed

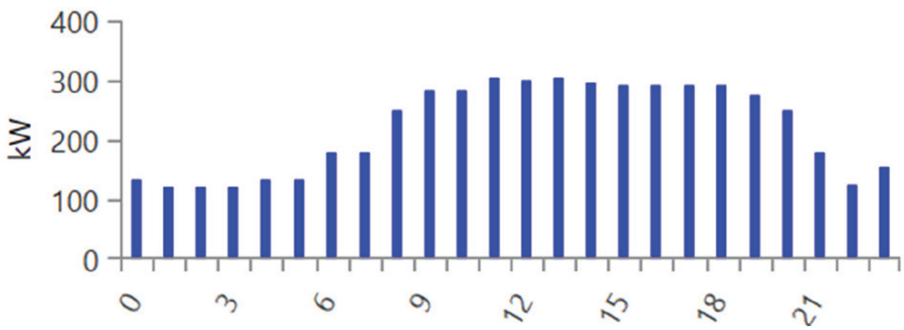


Fig.3: Load profile hourly

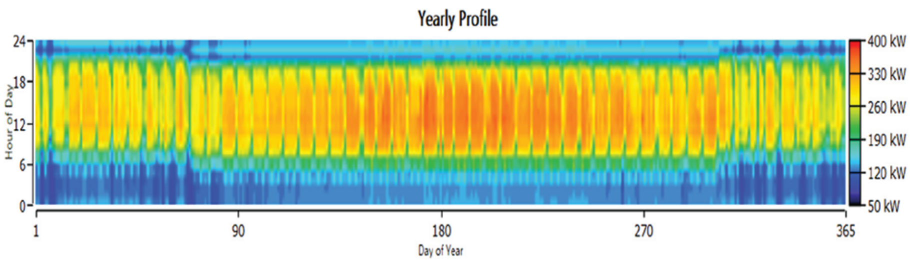


Fig.4: Hourly load distribution

TABLE 1: LOAD PROFILE

Metric	Baseline	Scaled
Average (kWh/day)	5,555.6	5,555.6
Average (kW)	231.49	231.49
Peak (kW)	389.89	389.89

profile is selected [8]. Homer loads the profile and shows the hourly load variations of the region for one complete year. In this paper, the average energy consumption from the load profile selected is 5555.68 kWh/d. The daily average load profile can be seen in Fig.4. 389.89 kW is the peak load consumption of the area considered, with a scaled annual average assumed as 5555.68 kWh/d. Fig.3 shows the load variations for 24 hours of the day.

3.0 Introduction to Homer

The hybrid optimization model for electric renewables (Homer) is used for designing standalone electric power systems that employ some combination of wind turbines, photovoltaic panels or diesel generators to produce electricity. Homer is an application software by the national renewable energy laboratory in the US. It is used for designing and analysis of smart grid systems by calculating different combinations of possible designs depending on inputs and then simulating the power system network. [8-9]. Simulation, optimization and sensitivity analysis are the main operations of Homer. Each hour of the year modelling of the power system network is done in the simulation process to determine the technical feasibility. Then, many different system configurations are simulated which meet the required demands and also follow the technical constraints in the optimization process. Finally in sensitivity analysis, multiple of these optimizations are performed according to the variable nature of the inputs. In the simulation process, it calculates four types of costs: NPC (net present cost) COE (cost of energy) O&M (operations and maintenance cost) initial capital cost the life cycle cost of a system is represented by the total net present cost (NPC) of the system. Cost of initial construction, maintenance, fuel, penalties from pollutants and all other costs are included in NPC. The average cost/kWh of useful electrical energy is cost of energy (COE).

4.0 Simulation model

Homer components are chosen to perform the simulation. Fig.6 shows the hybrid power system design using a wind generator, PV array, converter, battery and load. For economic analysis the following values have been used:

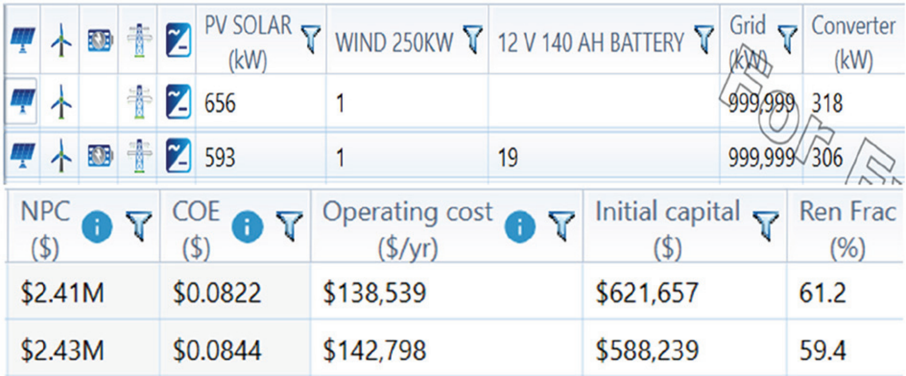
(a) Wind turbine: Generic 250 kW turbine manufactured by Generic has been used with a hub height of 48m and lifetime of 20 years. The capital and operation and maintenance costs are $50,000 and $500 respectively.

(b) Photovoltaic array: Generic 1 kW flat plate PV, manufactured by Generic has been used with a lifetime of 25 years and initial capital cost of $500 (each) and replacement and operation and maintenance cost being $30.

(c) Power converter: 30 kW system converter, manufactured by generic with efficiency of 95% and lifetime of 20 years with capital and replacement cost of $2300 (each) and operation and maintenance cost being $100.

(d) Storage bank: Kinetic battery model with 1.6 kWh nominal capacity and capacity of 140 AH. The storage bank can be used to store the excess electric energy after meeting the load demands for various other uses. It supports the system as it is not connected to the main centralized grid. Initial capital cost of $400 (each) and replacement and operation and maintenance cost being $40.

(e) Grid: The external grid is modelled as a component on the AC bus that



PV SOLAR (kW)	WIND 250KW	12 V 140 AH BATTERY	Grid (kW)	Converter (kW)
656	1		999,999	318
593	1	19	999,999	306

NPC ($)	COE ($)	Operating cost ($/yr)	Initial capital ($)	Ren Frac (%)
$2.41M	$0.0822	$138,539	$621,657	61.2
$2.43M	$0.0844	$142,798	$588,239	59.4

Fig.6: Optimization result (medium term)

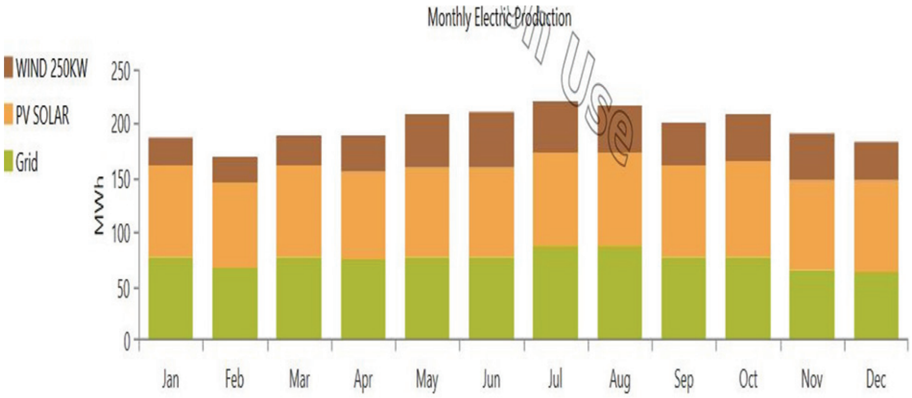


Fig.7: Distribution of production through various sources (medium term).

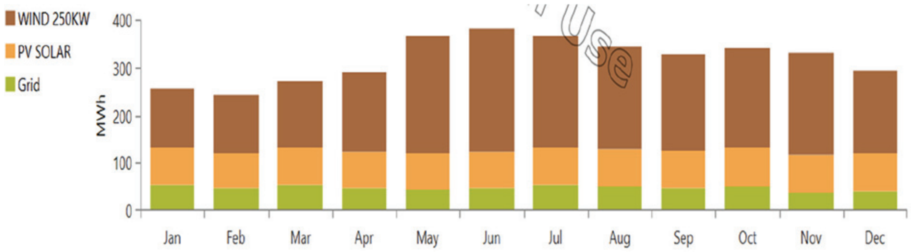


Fig.8: Distribution of production through various sources. (Long term)

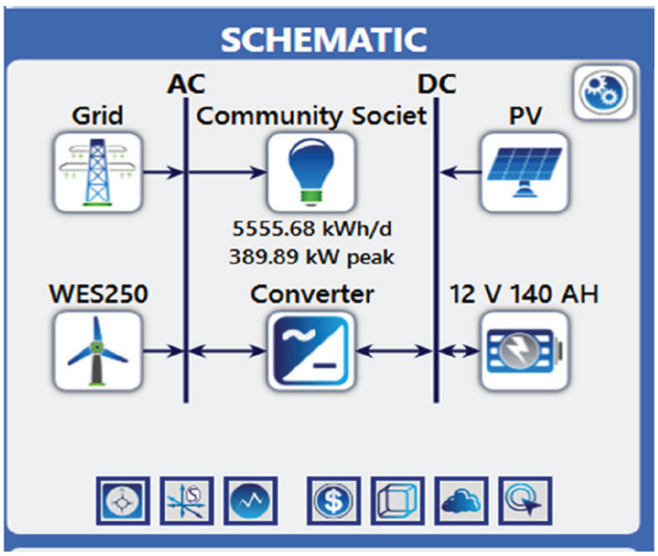


Fig.5: Simulation model

TABLE 2: ENERGY DISTRIBUTION (MEDIUM TERM)

Production	kWh/yr	%
Generic flat plate PV	1,008,107	42.5
Wind 30 (250kW)	459,059	19.3
Grid purchases	906,076	38.2
Total	2,373,243	100

TABLE 3: ENERGY DISTRIBUTION

Production	kWh/yr	%
Generic flat plate PV	935,747	22.1
Wind 30 (250kW)	2,754,355	65.2
Grid purchases	537,608	12.7
Total	4,222,710	100

serves the primary load. Here we can define its relationship to the system in terms of rate and interconnection performance. Grid power price taken as $0.14 per unit.

5.0 Optimization results

Homer software was used for estimation of optimal size, least NPC and COE with different configurations of the IERS. Furthermore, the hybrid system, once it has been implemented, has low O&M costs. For these reasons a grid hybrid system can be the most financially attractive and reliable solution. According to the simulation results the minimum COE obtained is $0.0822 in medium term and $0.0401 in long term and the renewable energy contribution is 61.2% in medium term and 86.5% in long term. The NPC comes out to be $2.41M. Fig.7 depicts the result obtained for the medium term.

6.0 Conclusion

This work shows that the optimization of available local energy resources can maximize the use of renewable energy resources by simulating the system through Homer programme. The result obtained for the total load of society of 5555.68 kWh/day and there is a requirement of 656 kW of the PV cell, 250 kW of wind energy generator, and 318 kW converter for the total initial cost of $2.41M. The operating cost was found to be $138,539 per year and the cost of the electricity produced is $0.0822/kWh. Once the system is installed, there will be increase in the share of renewable energy of 61.2% which can be further increased to 86.5% in the long term which will further reduce the cost of electricity to $0.0401/kWh.

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