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Paper Authors

Reem Abdelkareem, Mohamed Ali, Abdel Rahim Yousef

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Sizing and Analysis of Micro-grid System for 100 % RES for residential house Using HOMER Software

Reem Abdelkareem[1], Mohamed Ali[2], Abdel Rahim Yousef [3]

[1] Reem Abdel-Kareem (Master Student, Department of Electrical Engineering, South of Valley University, Egypt)

[2] Mohamed Ali (Prof. of Electrical Engineering, South of Valley University, Egypt)

[3] Abdel-Rahim Yousef (Lecture of Electrical Engineering, South of Valley University, Egypt)

Corresponding author: Reem882015@gmail.com

ABSTRACT : In this century, the world interested in renewable energy sources (RES) because of their advantages compared to traditional sources. This paper studies off grid 100 % RES for residential house. This residential house is located at Qena Governorate in Egypt country. Hybrid Optimization Multiple For Electric Renewable (HOMER) is a software tool which we used to size this system with minimum cost .By entering data for load demand, location and economic parameter for the system HOMER has simulinked an optimal sizing system with low cost .The final optimal system result is 4 kW PV, 4 wind turbine, 2 kW converter, 18 batteries, NPC $44, 697, house load 10 kW with 11% reserve load.

KEYWORDS : RES, Micro-grid System and HOMER Software.

I. INTRODUCTION

To face the growing need for energy with effectual cost method with taking into consideration the environmental, so a sustainable energy system has been in needed[1]. Such a system gives the possibility to develop sustainable to provide all people in all over the world an effective, safe and clean energy[2]. This is due to different resources such as lack of resources and Distance away from the grid. To solve these problems and reaching electricity to remote areas, there are two ways to solve these problems, the first way by using conventional methods to increase production of electricity and improving distribution and transmission network to supply remote areas with electricity[3].

The second way is by planning Renewable Energy Systems (RES). The first way is not a good choice because of environmental pollution, high cost, losses in distribution and transmission lines[4]. RES has advantages and disadvantages. RES has economic and environmental advantages. RES has intermittent nature so reduce its reliability[5]. The reliability problem can be overcome by integration many RES together or with conventional sources. Hybrid systems have more advantages such as high efficiency, more reliability, low cost and low capacity sources than using one source[6]. There are two type of

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operation of microgrids are off grid and on grid [1 assiout].

This paper study an optimal off grid 100 % RES for a residential house. Homer Optimization Multiple for Electric Renewable is a software tool has been used in optimizing and sizing the system. The optimal system which determined by HOMER has minimum Net Present Cost (NPC). Fig.2 shows the flowchart of homer economic analysis. The aim of this study is to design the 100% RES with minimum NPC. When looking at location of the house we find that the house is far from the grid so the available climatic conditions provide us with suitable solar radiation and wind speed the system consists of PV and Wind turbine integrated together to increase system reliability and Wind turbine to increase reliability of the system. Battery represents as a backup system.

This paper has been **divided** into sections: section 1: System description, Basic definition, Methods. Section 2 system components. Section 3 simulation results. Section 4 conclusion of the study.
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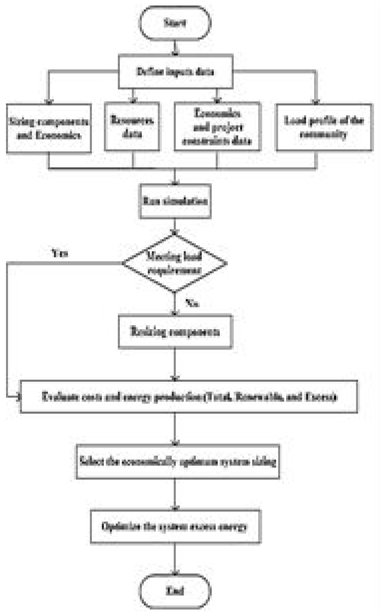

Fig. 1. Flowchart of economic analysis using HOMER software

2. System description

In this section, we described the input parameters, system components characteristics and economic parameters of the system which we had taken as a case study.

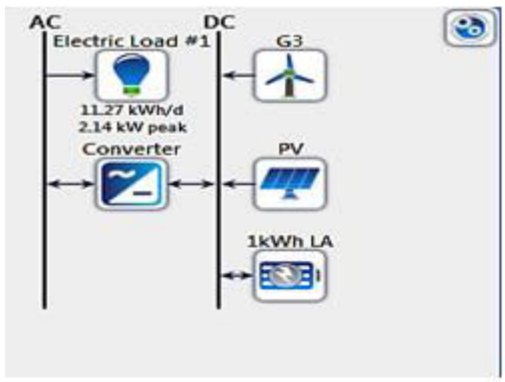

Fig. 2. Schematic representation of the system under study

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2.1. Site selection:

In this study, a standalone residential house in Qena Governorate in Egypt Country is considered as a case study. The area of this house is 180 m^2 and 40m^2 garden, geographical coordinates are 26".8 N, 52"6W[7].

Fig.3 Qena Governorate

The load demand was extracted from year electricity bills of the house. Fig 4,5 shows Hourly and average monthly loads of the house. The load has 11.27 kWh/day average and 2.14kW daily peak.

2.3. Solar resources

The solar radiation profile is required for this work. We obtained solar radiation from NASA Surface Meteorology and Solar Energy website [8]. For this region the average radiation is 6.15 kWh/m2/day.Fig.6 shows the solar radiation profile for a year period.

2.4. Wind speed

The wind speed data were obtained from NASA Surface Meteorology and Solar Energy website[9].

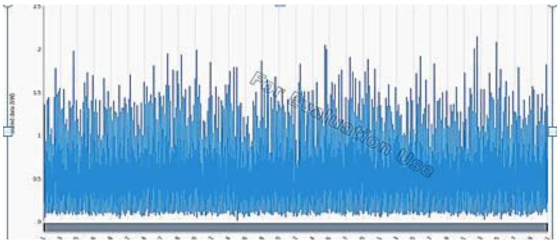

Fig. 4. Hourly AC load within a year (kW).

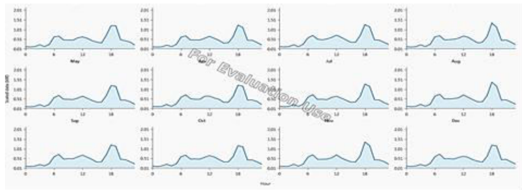

Fig. 5. Average monthly load profiles within a year.

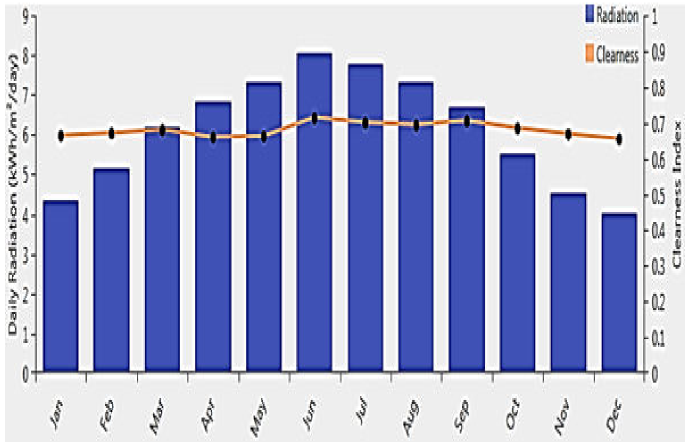

Fig.6.Solar radiation data.

Table 1: Cost assumption and life time for system component.

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Component	Investment cost ($/kW)	Yearly operation & maintenance costs ($/kW)	Replacement ($ / kW)	Lifetime(years)
PV	1420.7	30.2	1420.7	20
Wind turbine	1097	10.97	1097	20
Converter	600	30	600	15
Battery	800	16	800	20

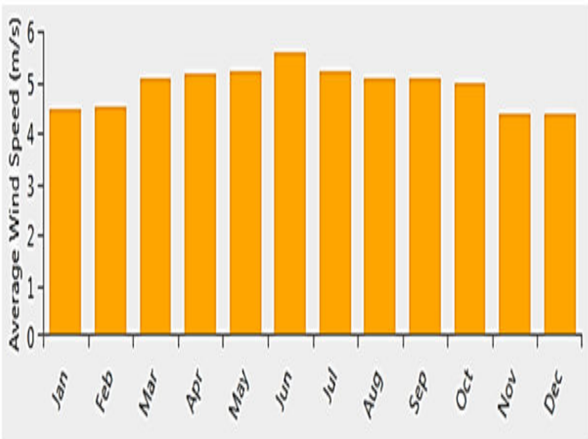

Fig.7.Average monthly wind speed (m/s).

2.5 System Component

2.5.1. PV panel

In this study PV panels data is obtained from Ref [10].The investment cost for PV panels is 1420.7$/kW, replacement cost is 1420.7$ /kW and operation / maintenance costs is 30.2 $ /kW .The PV panels power range is taken0,1,2,3,4,5,6,7 and 8 kW with derating factor 80 % and the slope of PV panels is taken

2.5.2. Wind turbine

Wind turbine data is obtained from Ref [11]. The wind turbine ranges are 0, 1,2,3,4 and 5 kW. This wind turbine investment, replacement and operation/ maintenance costs are 1097 $/kW, 1097 $/kW and 10.97 $/kW respectively

2.5.3. Battery

One of disadvantages of RES is intermittent nature that effected on fluctuation of production. In this study, battery has been used as back up to increase system reliability. The battery type is Trojan IND17-6V (with max capacity 1231 Ah and 7386kW energy). This battery range spaces are 0,2,4,6,8,10,12,14,16 and 18 strings. The investment cost for each battery is 800$, replacement cost is 800$ and operation / maintenance costs are 16 $/ yr.

2.5.4. Converter

To convert the PV panels DC output. In this study, an inverter with this data has been used: 600 $ investment cost, 600 $ replacement cost and 30 $ / yr. The efficiency of rectifier is 85 % and the efficiency of inverter is 90 %. The search spaces are 0,2,4,6,8 and 10 kW.

2.6. Economic parameters

The Net Present Cost (NPC) is all costs through the lifetime of the project. The aim of this study is to analysis 100 % RES with minimum NPC by using HOMER software tool. Investment, replacement, operation / maintenance and fuel costs which show in Table.1 are required in HOMER to calculate NPC by this equation :

$$NPC = C_{ann.} \frac{(1+i)^N - 1}{i(1+i)^N}$$

where :

C_{ann} is the total annualized cost.

¿ is the discount rate.

N is the project lifetime in years.

2.7. RESULTS & DISCUSSION

There are many HOMER simulations have been executed to obtain optimal system with minimum NPC. Fig.8 shows HOMER optimization result. The results have been indicated that, the system is consisting of 4 kW PV, 4 wind turbines, a 2-kW converter and 18 batteries with NPC 44.697$. Table.2. shows different costs the final result

Architecture					Cost			
PV (kW)	G3	1kWh LA	Converter (kW)	Dispatch	NPC ($)	COE ($)	Operating cost ($/yr)	Initial capital ($)
4.00	4	18	2.00	CC	$44,697	$0.841	$1,472	$25,671
7.00		18	4.00	CC	$59,527	$1.12	$2,536	$26,745

Fig. 8. Optimization Result of Hybrid Energy System.

Table.2: Optimum system costs:

Component	Capital Cost ($)	Replacement ($)	O & M ($)	Salvage ($)	. Total cost ($)
PV array	5,682.8 $	$0.00	$1,561.64	$0.00	7,244.44$
Wind turbine	$4,388.00	$1,398.93	$567.26	($788.38)	$5565.80
Battery	$14,400.00	$12,299.61	$3,723.12	($1,547.52)	$29,498.22
Converter	$1,200.00	$509.13	$775.65	($95.82)	$2388.96
Total	$25,670.80	$14,830.66	$6,627.68	($2,431.72)	44,697.42$

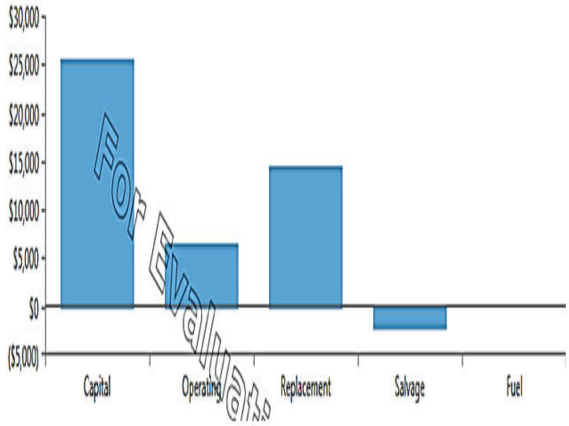

Fig. 9. Distributed costs of proposed system.

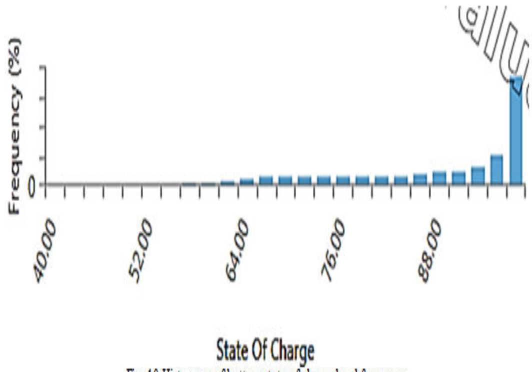

Fig. 10 Histogram of battery state of charge level frequency

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Table 3: Optimum system costs for base case

Term	Quantity	Units
COE	$0.841	$/kW h
NPC	$44,697	$
PV rated capacity	4	KW
PV mean output	21.3	kW h/d
PV capacity factor	22.1	%
PV total production	7,757	kW h/yr.
PV hours of operation	4,384	hr./yr.
Wind total rated capacity	12	kW
Wind mean output	.957	kW
Wind capacity factor	7.98	%
Wind total production	8,386	kW h/yr.
Wind hours of production	5,936	hr./yr.
Battery energy in	1,637	kW h/yr.
Battery energy out	1,314	kW h/yr.
Battery losses	328	kW h/yr.
Converter energy in	4,569	kW h/yr.
Converter energy out	4,112	kW h/yr.
Converter losses	457	kW h/yr.
Converter capacity factor	23.5	%
Converter Hours of operation	8,760	h/yr.
Renewable fraction	100	%
Co2 Emission	0	kg/yr.

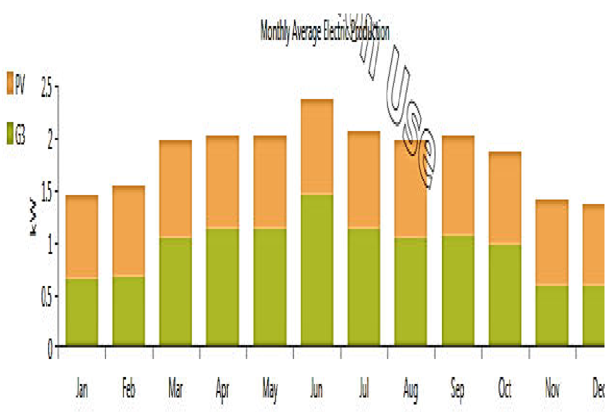

Table 4: Total power production and consumption.

Term	Quantity (kW h/yr.)
PV production	7,757
Wind turbine production	8,386
Total production	16,143
Ac primary load	4,112
Excess electricity	11,251
Unmet electric load	1.27
Capacity shortage	4.10

2.8 CONCLUSION

This paper explains how to design off grid 100 % RES for a residential house in Qena Governorate in Egypt country because this house is remote from the main grid with taking into consideration minimum cost. Because of high cost of grid extension. HOMER enables us to size that system with minimum cost and more reliable by integrated wind turbine with PV. The final optimal size of the system 4 kW PV, 4 wind turbine, 18 batteries and 2 kW converter with NPC $ 44,697.

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