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Zero Energy House in Iraq

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Abstract— The residential load is one of the largest components of the electrical load in the Iraqi power system. We can supply a part of the residential loads by utilizing the renewable energies. Recent research's show that the applications of a hybrid power system is preferable to achieve this goal. For residential loads connected to the grid (on grid) with the possibility of energy exchange (buying and selling) to the grid, the addition of suitable hybrid power system can reduce energy cost to zero (zero energy house). The paper studied the possibility of supplying residential load in the city of Mosul - at north of Iraq by using a hybrid renewable energy system to reach zero energy cost. The paper obtains this optimal hybrid system components for various cases. HOMER software was used to study the system to feeds the residential loads.

Index Terms— hybrid power system ; grid connecting; Residential load; Solar Water Heating; Zero energy building.

I. INTRODUCTION

The energy is one of the most important factors which affects and forms our daily life. Basic life requirements like water and food are also obtained and transported by the energy. For this reason, having high quality and uninterruptable energy is a basic requirement. Due to reasons like rising of fuel prices, energy needs, pollution and green house gasses, the use of environment friendly renewable energy sources are getting rapidly higher. Because of quite high renewable energy potential in our country, renewable energy systems are also getting popular. Renewable energy can be used in two ways; first for specific areas far from the grid (off grid) second for areas connected to grid (on grid) to provide part of the total energy demand [1]. Hybrid renewable energy plants (which invest more than one source of renewable energy at the same time) enhance the efficiency of renewable power stations in case of off-grid system. Also for grid connected system, by connecting a hybrid renewable power system (synchronized with the grid) to supply the shortages in energy as well as to export the excess energy to the grid [2]. Buildings have a significant impact on energy use and the environment. Residential buildings use almost 40% of the primary energy an approximately 50% of the electricity in Iraq [3]. A cost Zero-Energy Buildings (ZEB) receives as much financial credit for exported energy as it is charged on the utility bills. The credit received for exported electricity (often referred to net energy generation) will have to offset energy, distribution, peak demand, taxes, and metering charges for electricity and gas use. A cost ZEB provides a relatively even comparison of fuel types used at the site as well as a surrogate for infrastructure [3].

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A feasibility analysis to investigate the available renewable energy options was conducted using HOMER software. The net present costs, the cost of energy of each potential energy combination were considered in determining the most suitable renewable hybrid energy system. This study was carried on a house located in the city of Mosul - Iraq as shown in Figure (1) on the longitude coordinate 43.1558 east latitude 36.381 North's.

Figure (1): Iraqi Map.

II. AVAILABILITY OF RENEWABLE ENERGY RESOURCES

The paper suggests a hybrid system consists of photovoltaic cells, wind turbines, batteries and converters to feed the electrical load. The study area gets a large quantity of solar energy, the annual average solar radiation (5.2 kw/m^2/day). The annual wind speed is (4.6 m^2). Water's energy is excluded in this research because the studied area is fare from natural water resources. Figure (2) shows the rate of 22 years of the monthly average daily solar radiation.

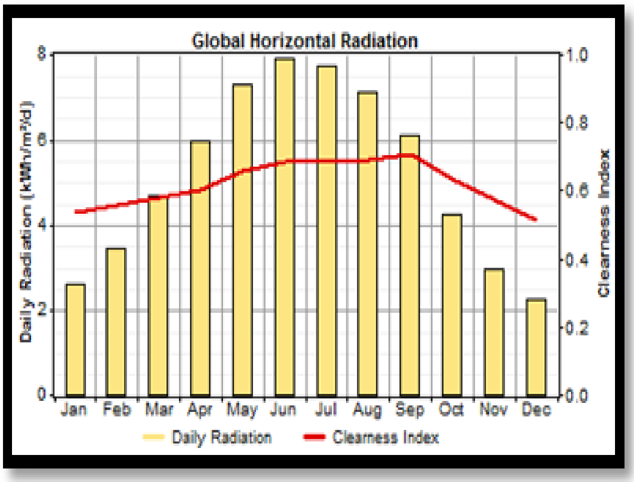

Figure (2) monthly average daily radiation.

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Figure (3) shows the rate of 10 years of the monthly average wind speed at height of 10 meters above ground level Figure (4) shows the monthly average of daylight hours. Figure (5) shows the monthly average of ambient temperature [4].

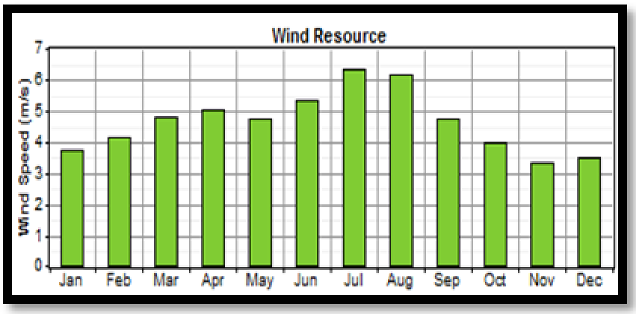

Figure (3): Monthly average wind speed.

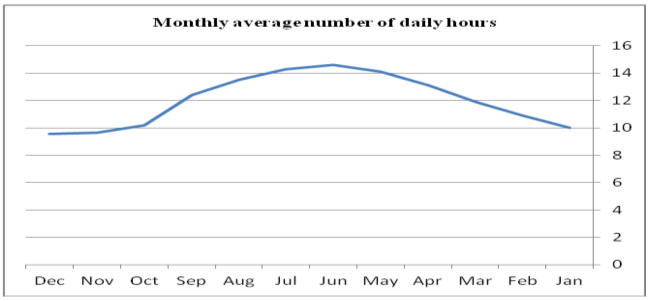

Figure (4): Monthly average of daylight hours.

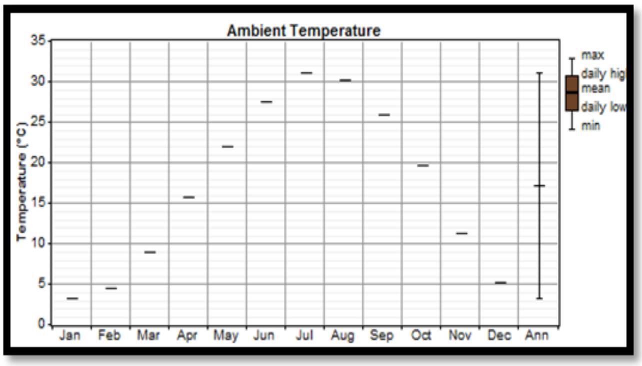

Figure (5): monthly average of ambient temperature.

III. Information Of Electrical Load

The monthly electrical load for the house is shown in Figure (6) below. Peak load is (7KW) and a daily average (28 KWh /day). The house area is ($200m^2$).

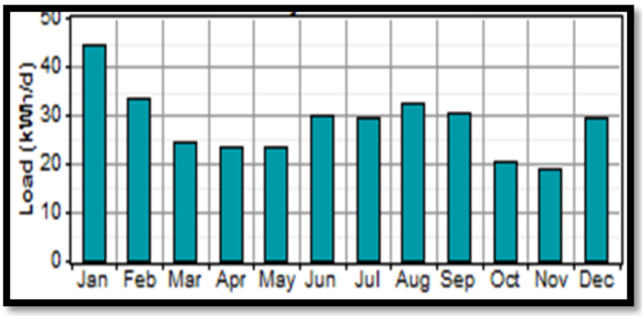

Figure 6: Monthly deferrable load for the house.

IV. Numerical Simulation

The goal of this study is to find the best feasible configuration of the hybrid power system by specifying the optimal sizing and operational strategy for a system. HOMER program is used for modeling and simulation a large number of possible combinations of hybrid system equipment. The HOMER Micro power Optimization Model is a computer model developed by the U.S. National Renewable Energy Laboratory (NREL) to assist the design of micro power systems and to compare a power generation technologies across a wide range of applications [5,6]. HOMER will simulate all the possible solutions of the hybrid system then displays a list of different configurations of the system (different combinations of the components of the system) arranged gradually from low to high in the total net present cost (TNPC). The optimal configuration of the hybrid power system is the least cost of other configurations [5]. HOMER can modeling small power systems in both types on grid and off-grid, which may contain any combination of PV modules, wind turbines , small hydro, biomass, generators with internal combustion engine converters, batteries, fuel cells and hydrogen storage[7].

A-Information of PV modules

PV panel rating (used in the suggested system) is 180W. The capital cost is 162 $ for each panel and the replacement cost $ 120. Each panel area is (1.27 m^2). The total PV system equipped with dual-axis tracking system carries all panels in the form of a matrix[8]. The life time for a PV system 25 years with a derating factor 90%. The ground reflectance is approximately 35%. The effect of temperature is considered.

B-Information of wind turbin

The average monthly wind speed in the studied area is equal to (4.6 m / sec). This low-speed is unable to rotate the turbines contain gearbox very well. Therefore, it is preferable to use a small special turbine commensurate with the wind speed of the region. The turbine do not contain gearbox, and begins to rotate at wind speed (0.2 m / s) and start to generate electricity at speed (0.9 m / s) until speed (17.9 m / s). The rated power is (1500 w) at wind speed (13.9 m/s). The capital cost per turbine is ($ 4,500) and the replacing cost (4000 $). Space occupied by the turbine is (2.5 m^2)[10].

C- Hybrid Renewable Energy Simulation

Electricity tariffs is Rising depending on the amount of consumption. Starting price is 1 cent (10 ID) for up to 2 or 3 or more depending on the value of consumption. So studying different electricity price 1-5 cents is considered. Hybrid system has been linked to the network as shown in Figure 7 in order to allow the import energy (buy from grid) and export excess energy (sell to the grid). The sale price has been adopted to be twice the purchase price of all cases.

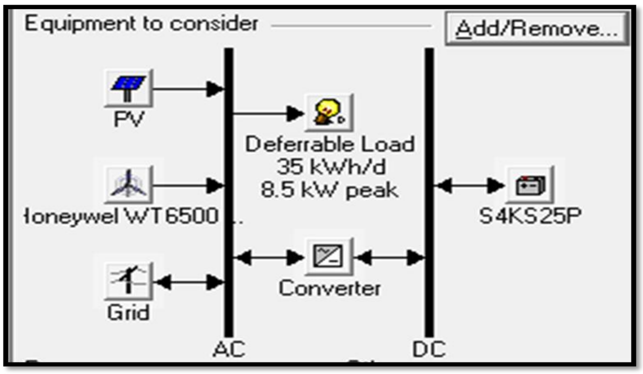

Figure 7: Hybrid system (On-Grid) shows the possibility of buying and selling power.

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The size of PV modules has been increased to make incoming financial return from the sale of surplus energy to the grid roughly equivalent to the cost incurred on the hybrid system. Optimal configurations that make the total cost close to zero are shown in the table1.

Table 1: Optimal configurations that make the total net cost of hybrid systems close to zero

G.E. Price (cent)	Grid (kW)	P.V. (kW)	W.T. (unit)	Batter (unit)	Conv. (kW)	I.C. ($)	N.P.C ($)	P.A.A (m^2)
1	4.4	0	0	0	0	0	2,887	0
2	4.4	0	0	0	0	0	4,496	0
3	4.4	7.92	0	0	0	7,128	4	55.8
4	4.4	6.23	0	0	0	5,607	2	44
5	4.4	5.47	0	0	0	4,923	13	38.5

Table 2: Energy generated and consumed, which makes the total cost close to zero.

	Production			Consumption		
G.E. Price (cent)	**Total Energy Produce (kWh/year)**	**P.V. (%)**	**G.E.P (%)**	**Load (kWh/year)**	**G.E.S (%)**	**E.E. (%)**
1	12,587	0	100	100	0	0
2	12,587	0	100	100	0	0
3	26,978	75	25	47	53	0
4	22,820	69	31	55	45	0
5	20,969	66	34	60	40	0

The results of table 2 show that the hybrid system is limited to supply the electric load from grid when energy prices are low (1 and 2 cents). PV modules are needed for higher prices 3 cents and above. PV modules gradually decrease with the increase in the purchase price of the network energy, because the sale of smaller amount of energy to the grid make adequacy profit that compensates the cost incurred by the hybrid system. Table 2 shows that the amount of energy sold to the grid gradually decreases as the energy price increases. This means that certain percentage increase in generation photoelectric will increase excess capacity in times of peak generation, which can be sold to the grid for the payment of expenses incurred on the system and this makes the net price cost (NPC) is equal to almost zero.

V. Solar Water Heating Utilization

Figure 8 shows the percentage of electrical energy consumed in water heating in every month of the year. The energy consumed in water heating for summer months (June, July and August) is equal to zero, due to high temperatures in these months.

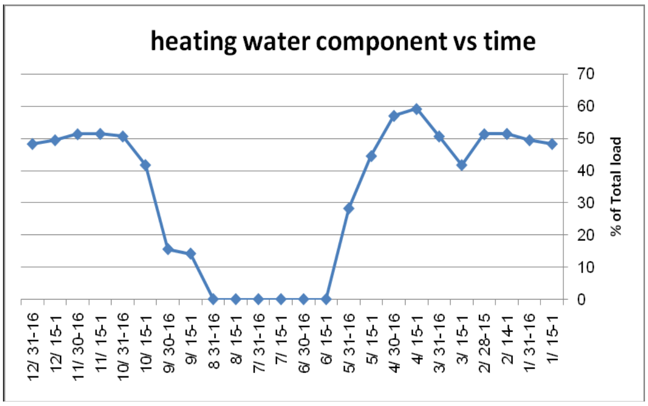

Figure 8: Percentage of electrical power consumed in water heating.

Water heating load component has been reduced by insulating a solar water heating. The solar water heating capacity is 250 L at a price of $ 550. Solar energy falling in winter is not sufficient to heat the water fully, so a small electric heater of 1 kW capacity is added to the solar water heating to provide supplementary heating. Figure 9 shows the percentage of the monthly supplementary heating (energy consumed in the added electrical heater). The addition of solar water heating result in (24.2%) load reduction. It becomes to be 26.2 kWh/day instead of 34.5 kWh/day. The peak daily load decreased to (6.4kW) instead of (8.5KW).

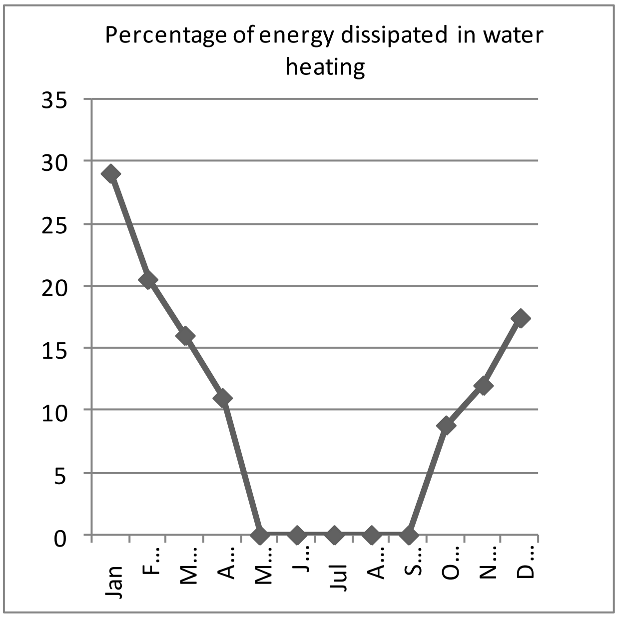

Figure 9: Percentage of monthly energy consumed in the electrical heater.

The hybrid system was simulated for this reduced load, the system is connected to grid to exchange energy (buying and

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selling). To make the consumer (NPC) equivalent to zero the network sales has been activated (selling price twice the purchase price). The addition of Photoelectric units to make the incoming financial return from the sale of surplus energy to the grid roughly equivalent to the cost incurred on the hybrid system, as shown in the simulation results in the table 3.

Table 3: Configurations and optimal costs of hybrid systems for zero NPC.

G.E. Price (cent)	Grid (kW)	P.V. (kW)	W.T. (unit)	Battery (unit)	Conv. (kW)	I.C. ($)	N.P.C ($)	P.A.A (m^2)
1	4.4	0	0	0	0	0	2502	0
2	4.4	0	0	0	0	0	3725	0
3	4.4	6.37	0	0	0	5733	1	45
4	4.4	4.96	0	0	0	4464	3	35
5	4.4	4.33	0	0	0	3897	8	30.5

The results of table 4 show that the hybrid system for low energy prices (1 and 2 cents) are limited to the load feeding from the electric grid. The needs for PV modules start at 3 cents. PV modules gradually decrease with the increase in the purchase price of the power of the network, because the sale of less energy to the grid make adequacy profit that compensates the cost incurred by the hybrid system. Table 4 shows that the amount of energy sold to the grid gradually decreases as the energy price increases.

Table 4: Energy generated and consumed for the hybrid system, which makes the total cost of the net close to zero.

	Production				Consumpti on		
G.E. Price (cent)	Total Energy Produce (kWh/year)	P.V. (%)	G.E. P (%)	Solar Heater (%)	Load (%)	G.E .S (%)	E.E. (%)
1	12,587	0	75.8	24.2	100	0	0
2	12,587	0	75.8	24.2	100	0	0
3	72,971	76	24	24.2	45	55	0
4	23,309	71	29	24.2	54	46	0
5	21,333	68	32	24.2	59	41	0

VI. CONCLUSION

Iraq is characterized by the availability of renewable energies, especially solar energy. The paper study of the possibility of using renewable energies to feed residential loads connected to the grid (on-grid), with the ability to exchange electrical energy (buy and sale) so that electrical energy cost become zero (zero energy house). HOMER software has been used in the analysis of the different cases in the study. Energy prices increased, in Iraq, as power consumption increase. So multiple quotations have been taken to be similar energy prices in Iraq. Residential electrical load consists of multiple components, lighting equipment component, heating and cooling devices component, water heating component . . . Etc. The optimum hybrid renewable energy system for residential load in Mosul city is found. The analysis has been repeated after the addition of solar water heater to reduce water heating component. It has been found in both cases the optimal hybrid renewable system to supply the residential electrical load. Also, the size of the components of the system are less in the second case. Therefore it is necessary to use solar water heaters to reduce the residential load.

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Mustafa H. Ibrahem, was born in Mosul, Iraq in May 1988. He received his B.Sc., In Electrical power engineering techniques from University of Mosul 2011 . He is currently pursuing his M.Sc degree. His major research interest include hybrid renewable systems in the houses.

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