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THE EVALUATION OF A PV-BATTERIES AND INVERTER POWER SYSTEM CONNECTED TO A GRID - SOLUTIONS FOR EMERGING SUSTAINABLE ENERGY IN IRAQ

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ABSTRACT

The impact of modern life requirements and climate change issues was a global interest that demand the instalments of different renewable energy components. The up-to-date IEA energy statistics shows that over-all energy-related CO_2 emissions reached their utmost global level at 30.5 gigatonnes ($GtCO_2$) in 2010, a 5% increasing from 2009. Because fossil fuels is a dominated power generation on the global measure, 2010 indicated another record in CO_2 emissions from electricity generation at 11.8 $GtCO_2$. In Iraq, because the shortage in electrical power plants, the national electricity grid was supported by a diesel generator units which are connected with grid and working as a secondary power plant, or an off-grid private units and distributed locally in the Iraqi cities. The results, more greenhouse-gas (GHG) emissions are growing. The integration of photovoltaic systems with buildings distributed worldwide to reduce fuel consumption and to minimize atmospheric pollution. In view of this, solar PV–Battery system promises lot of opportunities to cover part of the energy that supplied by grid directly or through diesel generators. The aim of this paper is to analyse solar radiation data of Baghdad city, to assess the possibility of hybrid PV–battery-inverter power systems to meet the load requirements of a typical domestic building annual electrical energy demand of 20.271 kWh/day. Baghdad city is located with longitude 44^o 4’ and latitude 33^o 3’. The monthly average daily global solar radiation about 5.52 kWh/m^2/day. The HOMER software used to realise the system evaluation. The simulation examines a hybrid system composed of 1,1.5,2 and 2.5 kWp capacity PV system together with 0,1, and 2 batteries storage and 1,1.5, 2 and 2.5kW inverter, the renewable energy fraction is 20, 29, 37, and 44%. The simulation indicates that, when we used a system with 2-2.5 kW PV module, the renewable fraction is increasing to (37%-44%), this increasing the COE value, which will be (0.12-0.144)US$/kWh.

KEYWORDS: PV, Battery storage, Solar radiation, Green building, Microgeneration.

INTRODUCTION

The effect of modern civilization requirements and climate change issues was crucial on a global interesting on installing different renewable energy components. The up-to-date IEA energy statistics shows that over-all energy-related CO_2 emissions reached their utmost global level at 30.5 gigatonnes ($GtCO_2$) in 2010, a 5% increase from 2009. As fossil fuels still dominate power generation on the global measure, 2010 indicate another record in CO_2 emissions from electricity generation at 11.8 $GtCO_2$, [1]. In Iraq, because the shortage in electrical power plants, the national electricity grid was supported by a diesel generator units which are connected with grid and work as a secondary power plant, or an off-grid private units and distributed locally in the all Iraqi cities. The fossil fuels are the main fuel supplied for 92% from the total working power plant, the results more greenhouse-gas (GHG) emissions, [2].

The nature of the climate of Iraq can be represented in a two typical seasons, short and cold winter and long, hot and dry summer with short periods of the moderate months. The daily temperature variation is very limited and causes to accumulate heat in the buildings of heavy mass, [3]. The use of cooling systems, in hot climate, is increased. In Iraq, with more than 6 million new residential building unit in 2020 , the rapid growth in building sectors become the largest consumer of electric power produced, where the building sector consumes more than 38% from the total energy produced, [2]. Iraq receives more than 3000 hours of solar radiance per year in Baghdad alone, [3].

The Iraq location with high intensity of solar radiation is a prospective candidate for deployment of photovoltaic (PV) systems. This investigation using Hybrid Optimization of Multiple Energy Resources called HOMER software for demonstrate the impact of installing microgeneration system from photovoltaic (PV) and inverter components within domestic building with on-grid scenario on the energy consumption from the grid and the solar energy fraction.

Information background

The HOMER (Hybrid Optimization of Multiple Energy Resources) is the global standard in microgrid software, based on decades of the needs of users around with an experience in designing and deploying microgrids and distributed power systems that can include a combination of renewable power sources, storage, and fossil-based generation (either through a local generator or a power grid),[4]. It includes extensive PV systems components databases, diesel generators, batteries, invertors as well as general solar energy tools.

This paper investigates the impact of PV penetration on grid energy consumption for domestic buildings, the system using HOME software for energy and data analysis. A global meteorological database software named Meteonorm7 used to generate a climate file for Baghdad city (33.3 ºN and 44.4ºE) as input data into HOMER software, [5].

Site climate information

Using Meteonorm7 climate data to generate a climate database for long period 1991-2010. The climate data sets interpolated from the satellite data for nearest climate stations from Baghdad city location. The Fig. 1, Fig. 2 and Fig. 3 shows the dry bulb air temperature in degree-centigrade (higher and lower limits), the global radiation in kWh/m^2, and sunshine duration in hour.

Fig .1: Daily maximum and minimum dry bulb air temperature.

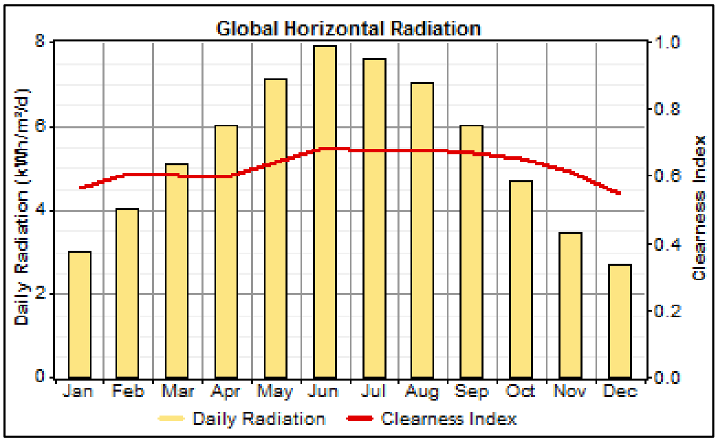

Fig. 2: Baseline data for Baghdad: daily solar radiation and clearness index.

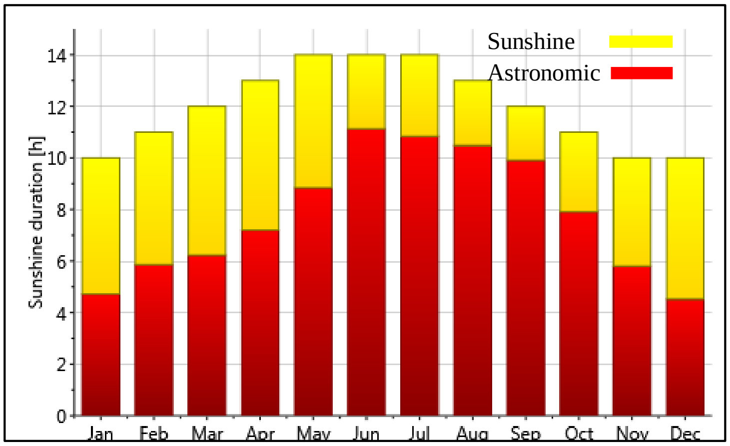

Fig. 3: Sunshine and astronomical sunshine duration.

Proposal user demand

In this study, the user demand shown in table 1, which represents a data taken for a proposed domestic house. From Fig. 4, the total connected daily load is 862.1 W and the load total capacity was found to be 20.271 kW h/day. The system consists of PV modules, batteries, inverter, and the required wiring and safety devices. The system arrangement diagram is shown in Fig. 5.

The PV modules produce a direct current (DC) electricity in direct proportion to the global solar radiation incident upon it, independent of its temperature and voltage to which it is exposed. The suggested PV panels to be used in the system simulation are 125 W at standard conditions and have estimated capital and replacement cost of 2.29 US$ /Wp, [6]. The PVs and their mechanisms require low maintenance (only a small part of their cost) and they have typically a duration life of 25 - 30 years. The panels were instilled as fixed and tilted south at an angle 33^{o} 3'. The analysis used a different PV panel's capacities (0, 1, 1.5 and 2 kW). The PV modules generate the necessary electrical power that can be stored in batteries, so when PVs produce a surplus of electric energy, they charge these batteries in order to use the storage energy later on. The battery used to storage has a 12-V, 200-Ah (Ampere-hour) capacity.

The estimated price of each battery is 0.23 US$ /W with 2 years lifetime. Different numbers of batteries (0, 1, and 2) were considered in this analysis. An inverter converts electric power from direct current (DC) to alternative current (AC). Its efficiency is assumed to be 90% for all sizes considered. The estimated price of an inverter is 0.711 US$ /W, and its lifetime is up to 15 years. Inverters of various sizes (0, 1, 1.5 and 2 kW) were considered in the analysis. Note that, in the prices of the PV modules, Batteries and inverter mentioned above, shipping and taxes were excluded, [6].

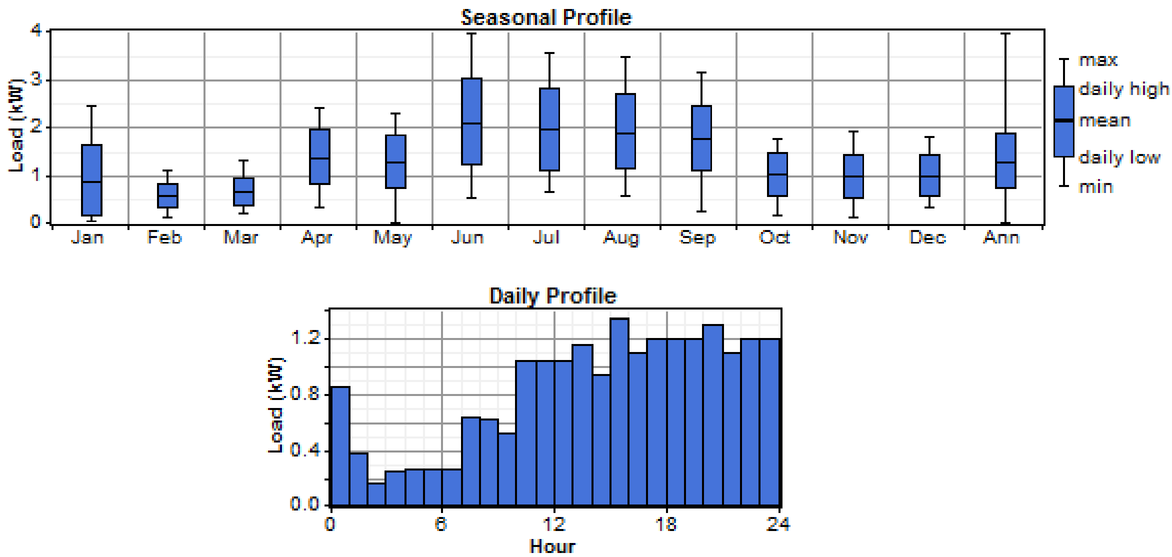

Fig. 4: Seasonal and hourly load profile.

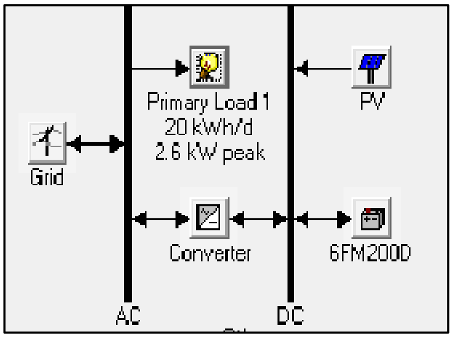

Fig.5: The system arrangement diagram.

Table 1: Proposed daily electrical load worksheet, the monthly load is 579376Wh/month.

Time/ h	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Fluorescents 7(night)	154	154	154	154	154	0	0	0	0	0
Fluorescents 8(day)	0	0	0	0	0	154	176	176	176	176
Refrigerator 1	110	0	0	110	0	110	110	110	0	110
Deep freezer 1	110	0	110	0	110	0	110	0	110	0
Waterpump	0	0	0	0	0	0	0	101	0	0
TV set(42' led)	0	0	0	0	0	0	0	0	0	80
Ceiling fan 4(day)	0	0	0	0	0	0	240	240	240	240
Evap. Cooler 2	0	0	0	0	0	0	0	0	0	440
Small appliance	0	0	0	0	0	0	0	60	60	0
Σload/h	374	154	264	264	264	264	636	687	587	1046

Continue.

11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
0	0	0	0	0	154	154	154	154	154	154	154	154	154
176	176	176	176	176	176	176	176	176	176	176	176	176	176
0	110	110	0	110	0	0	110	110	0	0	110	0	0
110	0	110	0	110	0	110	0	0	110	0	0	110	0
0	0	0	0	101	0	0	0	0	101	0	0	0	0
80	80	80	80	80	80	80	80	80	80	80	80	80	80
240	240	240	240	240	240	240	240	240	240	240	240	240	0
440	440	440	440	440	440	440	440	440	440	440	440	440	440
0	60	60	60	0	0	0	0	60	60	0	0	0	0
1046	1106	1216	996	1337	1090	1200	1200	1260	1361	1090	1200	1200	850
Per month=4week* 7day*$\sum_1^{24}(\Sigma load/h)$ = 579376Wh/month													

Table 2: summarized the deferent categorize connections used.

PV (kW)	No. of Battery	Converter (kW)	Initial capital $	Total NPC	COE $/kWh	Renewable fraction%
1	0	1	3001	6773	0.072	0.2
1	1	1	3526	7693	0.081	0.2
1	2	1	4051	8614	0.091	0.2
1.5	0	1.5	4502	9022	0.095	0.29
1.5	1	1.5	4671	9465	0.1	0.29
1.5	2	1.5	5552	10863	0.115	0.29
2	0	2	6003	11313	0.12	0.37
2	1	2	6528	12234	0.129	0.37
2	2	2	7053	13155	0.139	0.37
2.5	0	2.5	7504	13641	0.144	0.44
2.5	1	2.5	7673	14085	0.149	0.44
2.5	2	2.5	8554	15482	0.164	0.44

RESULTS AND DISCUSSION

Table 2 shows that the greatest optimal result is achieved when the system is composed of 1kW PV modules, (0, 1 and 2) batteries, and a (1, 1.5 and 2) kW inverter. The initial cost, net present cost NPC, and cost of energy COE for this system is (3001 US$ -3526 US$), (6773 US$ -7693 US$), and (0.072 US$/kWh -0.081 US$/kWh) respectively, the renewable fraction varied from (20%-44%). The simulation result also shows that the second optimum system is for 1.5 kW PV modules, (0-1) batteries, and a 1.5kW inverter, with 29% in renewable fraction. The simulation indicates that when we used a system with 2-2.5 kW PV module, the renewable fraction increased to (37%-44%), this increases the COE value, which will be (0.12-0.144)US$/kWh. Table 2, summarized the deferent categorize connections used in the analyses.

CONCLUSION

Using the HOMER software for model analysis, the different economic systems can be suggested for a domestic house in Baghdad city having a daily load of 20.271 kW h is composed of 1kW PV modules, 1 battery (200 Ah and 6 V), and a 1-kW inverter. The total initial cost, net present cost NPC, and cost of electricity produced from the system are 3762 US$, 7693 US$, and 0.081 US$/kW h, respectively, the renewable fraction 20% from the total energy supplied. The second choice is when we use a system of 2kW PV modules, 1 battery (200 Ah and 6 V), a 2kW inverter, 37% renewable fraction. The total initial cost, net present cost, and cost of electricity produced are 6528 US$, 12234 US$,

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and 0.129 US$/kW h, respectively. The third choice is when we use a 1.5kW PV module, 1 battery (200 Ah and 6 V), a 1.5 kW inverter, 29% renewable fractions. The total initial cost, net present cost, and cost of electricity produced are 4671 US$, 9465 US$, and 0.1 US$/kW h, respectively. The simulation indicates that when we used a system with 2-2.5 kW PV module, the renewable fraction increased to (37%-44%), this increases the cost of energy COE value, which will be (0.12-0.144)US$/kWh.

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