The Electric Energy Generation Approach of the Energy Saving House Using Photovoltaic System

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Abstract

This paper describes a research effort that aims of developing solar models for housing suitable for the Arabian region since the Arabian Peninsula is excelled with very high levels of solar radiation.
The current paper is focused on achieving energy efficiency through utilizing solar energy and conserving energy. This task can be accomplished by implementation the major elements related to energy efficiency in housing design , such as embark on an optimum photovoltaic system orientation to maximize seize solar energy and produce solar electricity. All the precautions were taken to minimizing the consumption of solar energy for providing the suitable air-condition to the inhibitor of the solar house in addition to use of energy efficient appliances and consideration the practices of the individuals and communities toward transferring useful and appropriate technologies for providing the required solar electric energy.
The analysis presented in this paper regarding the possibilities for energy-efficient housing reveals the potential savings in terms of energy and pollution. These findings will encourage the scientists to conduct more serious efforts in researching and development of the current study and implemented at various applications in this region.

Key words
PV system design, cost-effect, impact of the environment, energy conserving

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استخدام منظومة خلايا شمسية كنموذج لتوليد الطاقة الكهربائية لبيت حافظ للطاقة

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الخلاصة:

البحث يقدم نموذج تصميم لمنظومة خلايا شمسية لتزويد الطاقة الكهربائية لبيت شمسي ملائم للمنطقة العربية حيث تصنف شبه الجزيرة العربية كموقع يتميز بأستلام مستوى عالي جدا من شدة الاشعاع الشمسي . البحث يركز على تصميم لمنظومة خلايا شمسية تتحقق فيها كفاءة تحويل عالي للطاقة الشمسية واستثمار مبدأ حفظ الطاقة بأدخال العناصر الرئيسية التي لها علاقة مباشرة بكفاءة تحويل الطاقة الشمسية عند تصميم البيت الشمسي ومنها العمل في الحصول على افضل اتجاه للمنظومة لضمان استلام اكبر معدل كمية من شدة الاشعاع الشمسي على مدار السنة واتباع اساليب الهندسة المعمارية للتقليل من هدر الطاقة عند تصميم البيت الشمسي بالاضافة الى استخدام الاجهزة المنزلية ذات الكفاءة العالية لتحويل وحفظ الطاقة وتوعية الساكنين في البيت اهمية هذه العناصر لضمان ابقاء وجود الطاقة الكهربائية التي تتطلبها المعيشة في البيت على مدار اليوم والشهر والسنة .

إن إبراز هذه العناصر في تصميم المنظومة الشمسية يؤدي إلى تحقيق الهدف من البحث بالحصول على جدوى اقتصادية عند استثمار الطاقة الشمسية لتزويد الكهرباء الذي يحتاجه البيت الشمسي على مدار السنة اضافة إلى أن انتشار هذه الاستخدامات سوف يسهم بشكل كبير في الحفاظ على البيئة من التلوث. هذه الاسس التي توصل لها البحث تسهم وتشجع العلماء في اهمية التواصل بالعمل على تقديم نماذج من التصاميم لمنظومات أخرى للطاقة الشمسية في توليد الطاقة الكهربائية اللازمة لتطبيقات مختلفة في المنطقة العربية.

1.Introduction

Solar energy has the favorable circumstances of being free from environmental pollutions, sustainable and requiring low maintenance. However a solar photovoltaic (PV) and any solar energy systems depend strongly on geographical location and weather conditions. Therefore, successful design and installation of solar energy systems must be preceded by essential on-site experimental measurements to assess the full potential of the solar energy received at the installment site. In addition to radiation and weather patterns, solar PV output depends on the choice of the various system components such as solar modules, power conditioning units and storage batteries. Another important factor to consider after putting the system into operation is to design a control system to insure continuous maximum energy output and to protect or at least to minimize the reduction in output due to dust accumulation at the solar panel also to protect the system against any damage might cause by the sever and harsh climatic conditions at the install site of the PV array station. In order to have an answer to these points , the operation of the PV system under real climatic conditions must be known. Accordingly the current paper describes a research effort that aims for propose a design of solar house suitable for committee of middle east region.

A study case of the performance of propose system design for outdoor testing will provide these necessary data for supporting appropriate design of the PV power system adoptable to any specific climate conditions in this region.

2.Solar Energy Generators Utilization-Data Gathering and Analyzing

Various programs can be created to stimulate the used of solar energy, both hybrid and stand-alone system in several sectors[1,2]. Most PV performance monitoring studies have focused on initial evaluations of large hybrid connected solar plants [3-6] and output power optimization through maximum power point tracking (MPPT) control systems [7,8].Initial activities should be focused on identifying a cost-effective applications. A low size photovoltaic system is generally considered ready for implementation [9]. In order to establish a cost-effective system together with a proper design for any application, one should be first award of the major parameters that influence the daily performance of the PV system station. These parameters can be categorized in two mains fields:

2.1Measurements of Local Meteorological

The meteorological parameters include solar irradiance on horizontal and array planes, ambient temperature, sunshine duration and sun direction, wind velocity and its direction, and humidity. The measurement tools,their installment and the methodoloits including the technical guides for measuring and monitoring these vital parameters can be found in main textbooks of this fileds, this can be accomplished by referring to the refernces [10 -11].

2.2Minimizing Load Demand

There are many approaches rise up as significant recommendations to minimize the PV system size,
these are as follows :

- Architectural-style procedure

Established a proper architectural design can be achieved by taking into account the most effective methods to cool the house naturally.This can be done by keeping the heat away from building up through roof, walls, and windows. Particular procedure can be adopted to control heat gain exist. These methods are included a reflecting heat away from the house, blocking the heat, removing built-up heat, and reducing heat-generating sources inside the house. In this regard many techniques can be employed to manipulate the factors which has a direct effect to load demand such as windows orientation , insulation materials, as well as the shading and land scaping forms [12].

- Passive cooling system approache

Passive cooling system design is relatively easy but efficient approach for utilized some fundamental physical phenomena aiming for minimized the temperature alteration inside of the solar house regardless the outside ambient temperature, also this manner is used to take away the excess heat energy from inside to outside of the solar house [13].

- Utilzation of insulation materials & constructional designs propostion

One of the most important parameters which has major role in utilized passive cooling phenomena is to choose the right heat insulation materials that match the building requirements, from both price and quality points of view. The higher the material resistance to heat flows, the better the material insulates, and lesser the thickness is needed . Hence, on designing the appropriate thermal insulation of the house, many parameters would be considered like weight, convective heat loss and the cost [13].

- Estiminting the actual electric loads demand

A proper way for find out the electric loads demand can be accomplished by referring to the mains parameter which has a direct effect for the sizing of the PV array such as the actual amounts of total electric loads demand by the solar house throughout the year .In this regard the electric household appliances that fit the social conduct should be used, where high efficient appliances that offer the same performance at minimum amounts of electric power consumption will be considered. On the same line of saving the energy consumption a complement scenario can be adopted to gain additional saving in electric energy, that is using non-electric appliances especially those worked on solar thermal energy, such as a solar thermal water heaters, cookers , refrigeration devices and other electric appliances needed to run the various activities of solar house occupants.

In advocate for utilizing the above mentioned approaches its lead to the actual active load demand and consequently the size of PV system will drastically goes down by such a considerable amounts, and this will have a major role for the cost of erection of the PV array station used to supply the electric energy needed to run the daily activities for the inhibitors of the solar house place at remote area .

3.Photovoltaic(PV)solar house-Design requirement

The size estimation of any solar system needs full information on two basic parameters: first, the amount of electrical power required by the load; and second, the amount of solar energy available at the site of the solar house [10]

- Stand-alone PV assambly - Study Case

The stand-alone PV systems usually place at areas far away from the allocation of the common social community settlement were the energy needed comes from conventional energy sources such as utility grid. Figure (1) shows a simple block diagram of typical stand-alone PV system required to supply the energy for running the normal activities of solar house which is located in remote-area and far away from the place of conventional sources of energy such as power station.

As a first step towards predicting the electrical energy demand, a certain house has been assumed with the requirements load necessary to run the normal house activities as listed in Table (1) along with an estimation of the both the electrical power required to run the load and the daily operating hours for each appliance throughout year taken into consideration all the precautions mentioned in previous paragraph . Figure (2) shows the estimated monthly daily average demands of electrical energy by the house appliances throughout the year. Refer to the information and data shown in Table(1), and adopting the proper techniques of active and passive approaches to minimize the energy consumption , together with the technical characteristic of the components of the PV station as shown in Table (2),according a monthly daily average demands of electrical energy needed to run the house throughout the year were calculated and tabulated in Table (3).

- Prediction of the size of PV array assembly

Consider the solar irradiance of the site of PV-array station and take United Arab Emirate(UAE) as typical place to install the PV stand alone station to provide the energy needed for settlement living at remount area . Figure (3) represent the average estimated values of the solar irradiance on a horizontal surface for Sharjah province [14-15]. A monthly rates of received irradiance per m^2 to the daily average demand of electrical energy by the solar house were calculated, throughout the year as shown in Figure(4). A precaution should be taken toward insurances of a reliable and sustainable supply of electrical energy required to run the normal activities of the solar house of all the months throughout the year. This task can be accomplished by sizing of PV array in according to the lowest rate of irradiance to electrical energy demand, which is shown in Figure (4) as a month of August. Therefore to overcome any possible shortfall between PV array output energy and the loads energy demand, the size of the PV system array must design in according the energy needed to run the solar house for the worst month in addition to a safety factor of 1.2 [16] which yields a PV deliver energy of value around 226,000 W.h.

- Surplus energy evaluation of stand-alone PV system

There is surplus of produce energy generated from the PV station alone assembly since the size PV array is estimated in according to the worst month, August. In gathering these informations together with the data tabulated in Table (3), the total daily average energy demand is calculated and its value round 150,000 W.h, and consequentially the final surplus PV energy is round 71,000 W.h. Therefore the overall annual surplus energy is 32% of the annual allover electrical energy deliver by the PV stand alone station as illustrated in Figure(5).Arrangements could be made to make use of such surplus solar energy by adding suitable electrical appliances to the solar house at the corresponding periods.

-The PV system size for solar house
Referring to the data shown in Table (3) one can deduced the information needed to calculate the require size for the station to run the solar house with the leads stated in Table (1), accordingly these informations are included the following:
-The average monthly daily of the total energy demand is around 152,000 W.h.
-The average monthly daily PV power demand is around **56.500** W
-Total daily energy is around 1730 W.h.

The PV power system must deliver power of around 585 W in order to meet the requirement for running all the applicants of the solar house throughout the whole day. Therefore the number of panels and the configuration of the station which can deliver required power can be calculated take into account the panel technical specifications listed in Table (4). This can be achieved through installing 75W solar modules, assembled in 4 series branches each branch comprise of 2 parallel modules [16] .The PV array station will be place at the site of the solar house at an optimum inculcation angle of 20^o which is agree with Alnajjar[17].
- Storage system calculation
The size of required storage batteries system can be calculated according to the maximum monthly daily average demand of electrical energy throughout the year, the number of days with no sun and technical specifications of batteries used to install the PV array as shown in Table (4) .Accordingly the specification of the storage system of the station require to run the solar house with no sun for two successive days is calculated . These demands specifications can be met by assembling 12 volt - 120 A.H. batteries in one parallel branch and the branch includes 4 series batteries same as shown by Alsabounchi [16].

5.Conclusion

Assurance of a reliable supply of electrical energy for all the months throughout the year can be achieved by sizing of PV stand alone array according to the lowest rate of irradiance to electrical energy demand, which is shown in Figure (3) as month of August. Consequently the optimum electric power of the array is calculated and its value around 585W and the solar panels placed at an optimum inclination angle of 20^o. This can be achieved through installing 75W solar modules, assembled in 2 parallel branches each consisting of 4series modules.
The storage batteries system is calculated according to the maximum monthly daily average demand of electrical energy supplied by PV array. Calculations show that the required storage batteries specifications are assembling 12 volt - 1605 A.H. batteries in one branch contain 2 batteries connected in series to meet the required specifications with no sun for two successive days.
The outcome findings of the current study case will enable the investigators to recognize the obstacles and challenges that are associated with real implementation of solar energy system for providing the electrical power to run any application in this area such as a constructed a PV- power stations to supply all the energy demands by the human settlement in villages located in remote-area. However there are many obstacles which restricted wide-scale implantation of these medium power PV systems. One of these major obstacle is the need of relatively big size battery storage units necessary for continuing supply of electricity demand, especially during the absent of solar radiation. This obstacle could be overcome by adaptation a backup generator theme through a connection of the PV system station to the conventional source of energy which act as an energy storage source for the PV array assembly. Accordingly, the PV

array size, as well as the cost, could be minimized effectively by installing a suitable diesel generator to support the PV system during the peak load periods. Figure (6) shows a typical schematic diagram of hybrid PV/diesel generator system.

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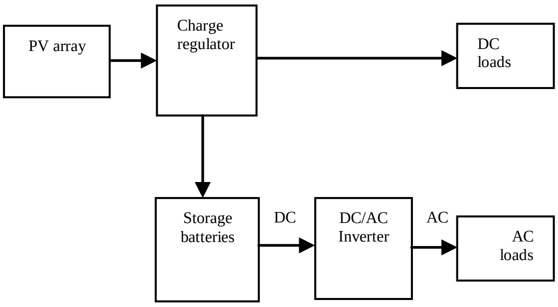

Fig.(1) Simple block diagram of typical stand-alone PV system

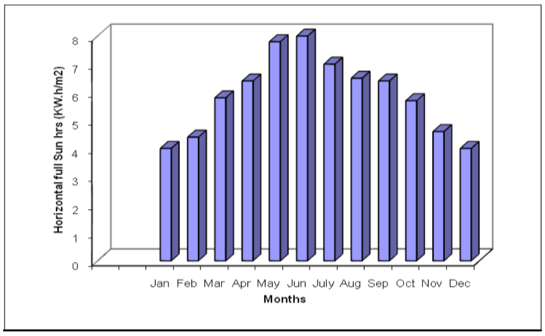

Fig. (2) : Average daily monthly energy demand by the house appliances throughout the year.

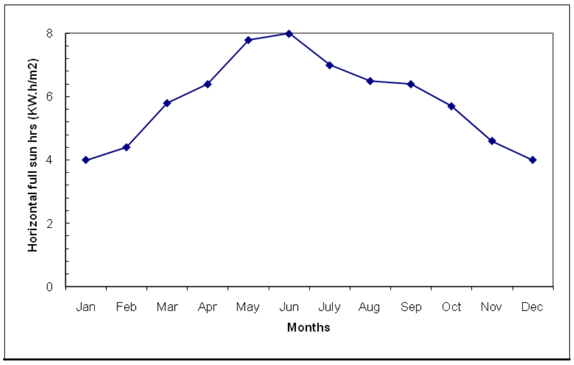

Fig. (3) : Solar irradiance on horizontal surface for Sharjah province, UAE[5].

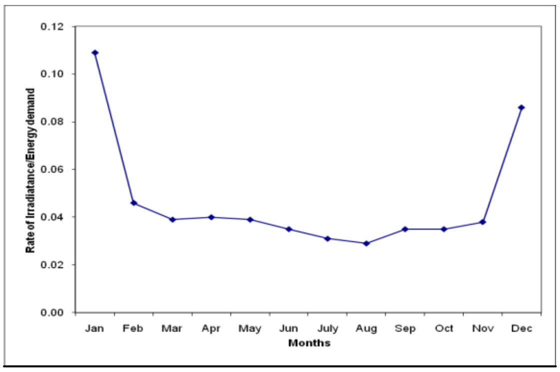

Fig. (4) Monthly rates of received irradiance per m^2 to the daily average

demand of electrical energy of the solar house.

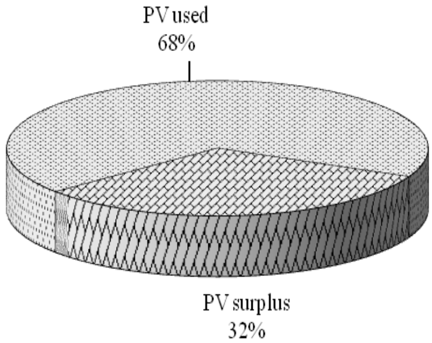

Fig. (5) : Percentage of the annual overall used and surplus energy deliver by stand-alone PV array

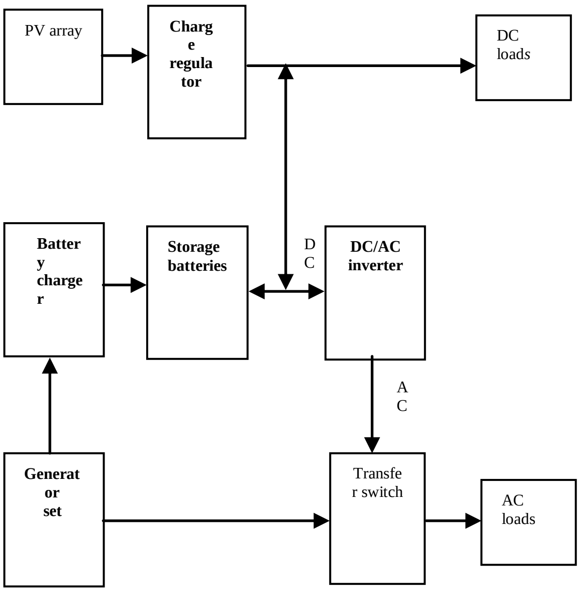

Fig.(6) Schmatic diagram of hyprit diesel- PV system station

Table(1): House appliances distribution

Loads		Power (W)	d.c. power (W)	No. of units	Daily hrs.	Dailyenergy(W.h)
Living room	Lamps	36	36	1	6	216
	TV	70	70	1	2	140
	Ceiling fan	30	30	1	3	90
Guest room	Lamps	36	36	1	2	72
	Ceiling fan	30	30	1	2	60
4 bed rooms	Lamps	36	36	2	1	36
	Ceiling fan	30	30	1	4	120
Common room	Computer	70	82	1	2	164
	Air-Cool	70	70	1	4	280
	Lamps	18	18	1	4	72
Kitchen	Lamps	18	18	1	1	18
	Electrical appliance	35	35	1	3	105
bathrooms	Lamps	18	18	1	1.5	27
Corridors	Lamps	18	18	1	2.5	45
Refrigerator		70	70	1	4	280

Table (2):Technical specifications of the tools comprise the PV array station

Battery efficiency	Controller efficiency	Inverter efficiency	Regulator efficiency	Temperature degrading factor
0.8	0.95	0.85	0.95	1.00

Table (3) Total monthly daily energy demand and PV- peak power

units	kW.h/m^2		W.h/m^2	W.h	W	W.h	W.h	W.h	W.h
Month	Horizontal full sun hrs.	Tilt factor	Total daily full sun hrs.	Total energy demand	PV power demand	Possible PV energy	Final net PV energy	Total used PV energy	Final surplus PV energy
Jan	4.000	1.296	5.182	36,625	11,159	185,340	148,715	36,625	148,715
Feb	4.400	1.184	5.210	96,625	29,284	186,322	89,697	96,625	89,697
Mar	5.800	1.095	6.352	148,725	36,971	227,155	78,430	148,725	78,430
Apr	6.400	1.000	6.400	160,425	39,581	228,870	68,445	160,425	68,445
May	7.800	0.925	7.212	198,275	43,411	257,913	59,638	198,275	59,638
Jun	8.000	0.889	7.115	226,025	50,159	254,457	28,432	226,025	28,432
July	7.000	0.915	6.403	226,025	55,734	229,001	2,976	226,025	2,976
Aug	6.500	0.972	6.320	226,025	56,468	226,025	0	226,025	0
Sep	6.400	1.064	6.811	181,025	41,969	243,567	62,542	181,025	62,542
Oct	5.700	1.191	6.791	161,175	37,476	242,855	81,680	161,175	81,680
Nov	4.600	1.302	5.989	119,875	31,604	214,188	94,313	119,875	94,313
Dec	4.000	1.350	5.398	47,875	14,003	193,062	145,187	47,875	145,187

Table (4) Technical specifications of the PV system array

PV panel specification	The battery specification
Module specifications at STC P_m =75W, V_{pp}= 16.9 V, I_{pp}= 4.437 A , I_{sc} = 4.792 A Maximum ambient temp =50^{o}C Nominal PV array voltage 48V Approximate minimum V_{pp} of module =13.3V Maximum I_{pp} of the PV array =8.874 A Minimum V_{pp} of the PV array = 53.20V Nominal load voltage= 48 V Actual PV peak power demand =600 W	Capacity (Ampere hour) 115 A.h , Voltage: 12 V Peak : 0. , MDOD , CR 35 Battery system vge. = 48 V Theoretical batteries system capacity =120Ah End of charge vge= 55V Actual batteries system capac. =115 Ah Min.end of charge vge = 52.90V Maximum limit of batteries capacity =335Ah Daily MDOD= 0.312