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Optimal sizing of photovoltaic systems using HOMER for Baghdad

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***Abstract*— In this study, the weather conditions data for Baghdad City such as temperature, solar radiation intensity, relative humidity and wind speed were used in Homer program to determine the optimum system of solar-powered lighting to The Energy and Renewable Energies Technology Center at the University of Technology. Homer can be regarded as the closer global program utilized in such post.**

The proposed system presumed design was employing a group of Photoelectric cells with a total production equal to 8 kW. The primary cost of the proposed systems was in 2000 US$. Also, the current net cost of the system is 32015 US$, and the cost of electricity produced 0.903 US$/kW. The study proved that the use of solar cell systems in the city of Baghdad financially acceptable and laws and regulations must be legislated to facilitate its utilization widespread.

***Index Terms*— Photovoltaic; Solar System Design; Optimization; HOMER; Baghdad City**

I. INTRODUCTION

THE sun is the source for all energies on the globe, and what reach the surface of the earth is a fraction from which it produces, this sun rays come to us as an electromagnetic radiation after crossing the atmosphere, and the greatest intensity is 1.4 kW/m2 [1] . Certainly, the intensity of solar radiation values varies from one area to another depending on its latitude, longitude, the weather conditions, and the quality of its air [2]. Air dust and the pollutants lingering in the air could scattering solar radiation and thus reduce its intensity. In fact, when compared to any solar system with another operates with fossil fuel on the system occupied space basis; we find that the solar PV system needs much larger areas [3]. What distinguishes the solar energy is that it is free and available [4]. It can be converted directly into electricity using solar cells [5]. Solar PV system consists of a group of arrays tied together in parallel or in a row, a convertor that converts the DC output from the cells into AC, a regulator that controls the output trend. In addition to all that, a group of batteries to store the produced energy to be used in other times [6]. The solar cell systems can connect to the grid and become part of it, also it can be used as a stand-alone system [7].

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The expense of fossil fuel based power era in the long haul may increment, and the generation costs of renewable vitality innovations diminish because of development enhancement and more prominent proficiency. The issue is finding a fitting beginning stage and improvement situation for the utilization of renewables in Baghdad that may prompt the zero carbon conditions. Raw petroleum is still the real wellspring of Iraq's economy [8].

These projections are situated to some extent on the current use of non-renewable and renewable energies. Subsequently, to lessen the crevice amongst generation and utilization, extra use of vitality sources other than fossil oil and gasses are required. In such manner, renewable energy sources (RES) give off an impression of being the standout amongst the most productive and fruitful arrangements [9].

Sunlight based vitality in Baghdad observed to be among the most noteworthy universally. The area of Baghdad is in the Middle East. The longitude and scope of Baghdad are (44 23E, 33 23N). It is exceptionally hot, with temperatures achieving 50◦C in the hot season. Moreover, the atmosphere of Baghdad stays dry (no precipitation) and singing. In this way, it is found that sun oriented PV innovation is appropriate creating power for use in Baghdad [10]-[11]. The common worldwide even yearly sun based asset is 5.19 kWh/m2/day [12, 13].

The photovoltaic solar cell efficiency and productivity are affected by weather conditions like temperature, solar radiation intensity, relative humidity, wind speed, and dust. So, the Baghdad city weather conditions will determine the productivity of the solar cell. Since the city of Baghdad, enjoying a shiny atmosphere up to 330 days/year, and a solar radiation intensity ranging from 220 W/m2 in the winter to 980 W/m2 in summer, and an acceptable relative humidity of 45-55%, wind speed that do not exceed 5 m/s most the year; these conditions are considered suitable for the use of solar cells. Perhaps, the most prominent determines the use of solar cell systems are dust and pollution accumulation on solar panels surfaces, which has been studied by many researchers and appropriate solutions for it were found [14-15].

HOMER, the smaller scale power enhancement programming created by Mistaya Engineering, Canada for the National Renewable Energy Laboratory (NREL) USA, utilized as a part of this examination rearranges the undertaking of assessing outlines of both off-network and matrix associated power frameworks for an assortment of uses [16 & 17]. In building up a control system, numerous choices about the setup of the plan are to be made: parts to incorporate into the system outline, the span of every component to utilize, and so forth. An extensive number of innovation alternatives and the

variety in innovation expenses and accessibility of vitality assets settle on these choices included. HOMER's enhancement and affectability investigation calculations make it less demanding to assess the numerous conceivable framework arrangements [18].

Homer software operates simulates through making the energy balance calculations and offers several convenient options by list, in order of preference in terms of the total price, which is considered as the main thing that the designer should think about. This program has been used to design and create solar systems models for thousands of times, and was employed by a large number of researchers due to its success and reliability [19-20].

Reference [21] used Homer program to develop and design a stand-alone solar cells system used to equip health clinic in rural areas of southern Iraq. The design was based on the operating system's daily capacity of 31.6 kW, solar panels composed of a capacity 6 kW, 0.80 battery (225 Ah and 6 V), and 3 kW inventor.

The program provided a primary system at a primary total cost of 50,700 US$, while the net present cost was 60,375 US$. The program showed that the cost of electricity generated by the system was 0.238 US$/kW h. As the studied area was remote, the results of the study showed that the cost of electricity produced from diesel fuel is four times than the cost of production of the solar system. This result means that the use of the proposed system is an excellent option in remote areas such as the studied regions.

Reference [22] proposed an enhancement arrangement of a mixture arrangement of renewable vitality by utilizing the Homer programming for remote zones in Tunisia. Hybrid systems that work with a variety of energy resources could use wind, solar cells, and diesel generators, in addition to the batteries. The researcher suggested the possibility of using two systems the first consisted of (wind/PV/batteries) and the second system was (diesel generators /battery), depending on the weather conditions of the studied area (Hawaii in Tunisia). The study showed that the (wind/PV/battery) system was ideal for the studied area at an elementary cost up to 165.450 US$, with an operation cost up to 2.102 US$/year. The proposed system was made of 8 kW PV arrays, and solar power converters capacity of 12 kilowatts, 0.118 battery, and two wind turbines. This makes the equipped system electricity price is 0.540 US $ / kWh. The researcher compared his proposed hybrid system with the diesel/battery system, and found that the optimal design was such a system that using a diesel generator of a 5 kW, 18 kW battery and two converters. The primary cost of the system was 11.934 US $, while the operating cost of 10.707 US$/year. This system made the electricity cost about 0.382 US$/kWh. The researcher suggested adding the diesel generator to the hybrid system as support system, in case of emergency, and to ensure a stable processing away from changing weather forecasters.

Reference [23] studied the design of a system to supply electricity for 10kW Telecommunication Tower in Al-Buraimi City, Oman. The authors used Homer software to provide optimized solution for employing Hybrid Power Systems consisted of PV/Diesel Generator. The study results manifested that 50 kW PV arrays system is suitable for this mission. The software showed that the costs solar energy is about 143.402US$, the net present expense of the system is 324.569$, and the electricity cost is 0.29 $/kWh. When compared to a diesel generator, the electricity cost was 0.584$ while the PV system electricity cost was 0.344$. The study revealed that using Hybrid system for powering telecommunication tower in Al-Buraimi, Oman is the optimum option based on the electricity cost.

Reference [24] used Homer software to study the possibility of constructing a system consisted of solar PV/ wind in Nigeria at the cheapest cost. The proposed system has been compared to several other systems. The study showed that the cost of producing electricity from the grid is cheaper, but may not be available to everyone, especially the remote areas of Nigeria. Homer software suggested using a system composed of (0.05 - 0.4 kW) PV board with (0.4 kW DC) FD arrangement, and (0.1 - 1.5 kW) converter, wind turbine, and (200 Ah/12 V), bank size: 1-8 batteries.

Reference [25] discussed the electrical energy requirements for an isolated island of Masirah in Oman. The authors foxed on using renewable energy sources with the existed diesel power generators. Solar and wind energy were used in this study. The study used Homer Program to design hybrid Solar/Wind/Diesel/Battery system, and to evaluate the system cost and pollution. Four variable systems were studied, PV/wind/diesel/battery, PV/diesel/ battery, wind/diesel/battery, and diesel generators only. The results revealed that a reduction in the cost of energy of 75% can be gained by using PV/wind/diesel hybrid power system. The fossil fuels combustion emissions reduced about 25% when this proposed system is utilized. The study concluded that the solar/Wind/Diesel hybrid system is a suitable option for Masirah Island from cost and emissions point of view.

This paper depicts the planning and usage procedure of PV framework Baghdad utilizing HOMER programming. The electrical requests are recorded and structure plan streamlining is done taking into account hourly information measured in Baghdad. This work is a part of the Energy and Renewable Energies Technology Center to instruct and spread mindfulness in the benefits of renewable energies use [26-70].

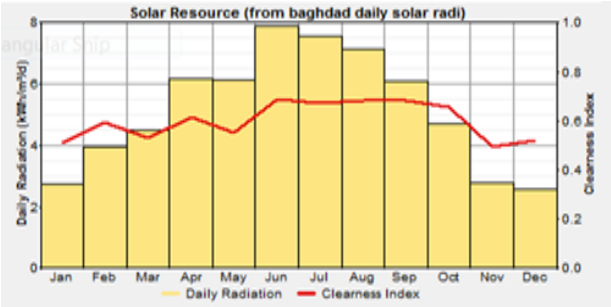

Fig. 1. Solar radiation profile

II. The Proposed System Description

The generated electricity by the PV panels comes out as DC current (power generator) and must be inverted to AC by means of inverter to supply appropriate load. This electricity

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can be used at night by using the battery (storage mechanism). Batteries used for this purpose must have a large storage capacity. Therefore, the proposed system will consist of PV panels, inverter, batteries, and electric circuit breakers and cables in order to equip the specified load.

A. PV Array

The solar panel consists of a semiconductor that absorbs energy photons from sunlight and turning it into a voltage causes the movement of electrons. The PV cells are connected together to produce a unit. The establishing and the replacement cost of the PV system estimated up to 2,000 US$/kW. It is supposed that the estimated age of the solar panel is 15 years with the use of up to 80% derating factor for the production of electrical energy. The fixed panels tend to the south at an angle equal to the width of the site line (01, 2, 3, 4,…, and 10 kW) and different capacities resulting from the panels depending on the operating and construction conditions.

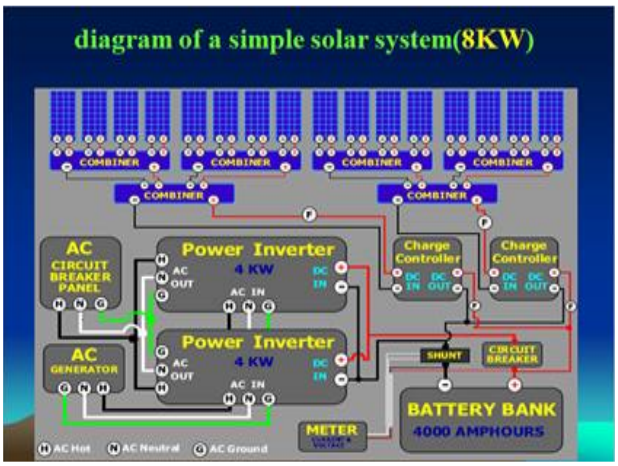

Fig. 2. Block diagram of PV system [3]

B. Batteries

As the framework considered working 7 hours in day five day in the week, battery and controller were additionally shaped as a primary part of the system. For the duration of battery lifetime, HOMER expects that the properties stay steady and not affected by outer elements, for example, temperature. The picked battery has a12 V, 200 Ah limits. The battery value assessed to be 300 US$. Its lifetime is thought to be 917 kWh of throughput for every battery. A unique number of cells considered in this investigation (0, 1, 2, 3,… ., 70).

An inverter is a circuit changes over DC energy to AC. Its productivity is thought to be 85 % of all sizes considered. The assessed cost of an inverter is 300 US$/KW, and its lifetime is up to2.5 years. Inverters of different proportions (1, 2, 3, 4, and 5 kW) were considered in the investigation.

The proposed burdens are traditionalist vitality burden in correlation with the heap sort utilized nowadays as a part of Baghdad. It is speaking to the average everyday power that is used by family likewise; we attempted to characterize the measure of vitality that the PV framework must produce day by day. The hourly load profile is utilized to light the Renewable Energy Center at the University of Technology is appeared in figure 4. The normal everyday load interest is ten kWh/day, with a crest power is equivalent to 3.6KW.

III. The Proposed System Optimal Size Design Employing HOMER

As specified before the framework comprises of; PV modules, batteries, charge controller, inverter, and the basic wiring and wellbeing gadgets. The framework attainability investigation was performed utilizing the HOMER programming. HOMER is a PC model that rearranges the undertaking of assessing outline alternatives for both off-lattice and network associated power frameworks for remote, remains solitary, and dispersed era (DG) applications

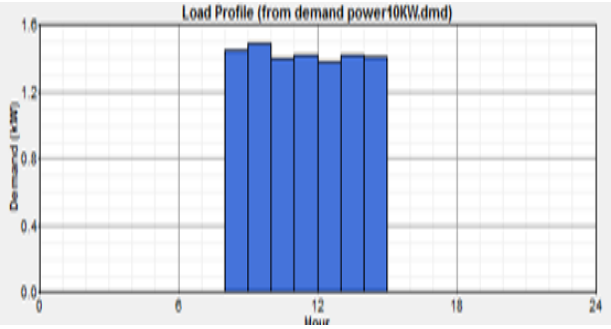

Fig. 3. Hourly load profile

HOMER's enhancement and affectability examination calculations permit one to assess the financial and specialized achievability of a substantial number of innovation choices and to represent variety in innovation expenses and vitality asset accessibility. HOMER models both traditional and renewable-vitality advancements [3]. HOMER models a force framework's physical conduct and its life-cycle cost, which is the aggregate expense of introducing and life range. HOMER permits the modeler to think about a wide variety of outline choices because their functional and monetary benefits. It likewise helps with comprehension and evaluating the impacts of vulnerability or changes in the inputs. Figure 5 demonstrates the schematic chart considered in the enhancement. The gear's considered are PV, converter, battery bank and stacking framework.

A. PV Array Data

Fig. 4 shows the construction and replacement costs of a PV arrays which was identified about 2,000 US$. The program demonstrated that the maintenance costs of the panels didn't exceed about 10US$/year. Also, it considered the life span of the panels up to 15 years without a decrease in its productivity.

B. Battery Data

HOMER considered 20 batteries in the reproduction appeared in Figure 5. These batteries were from vision 6 fm 2000 D. It has an ostensible voltage of 12 Volts and notable limit of 200 Ah (2.4 kWh).

C. Inverter Data

Fig. 6 represents the inverter effectiveness proposed by Homer software. The inverter efficiency for all the size considered to be about 85%. The suggested size found was 4 kW.

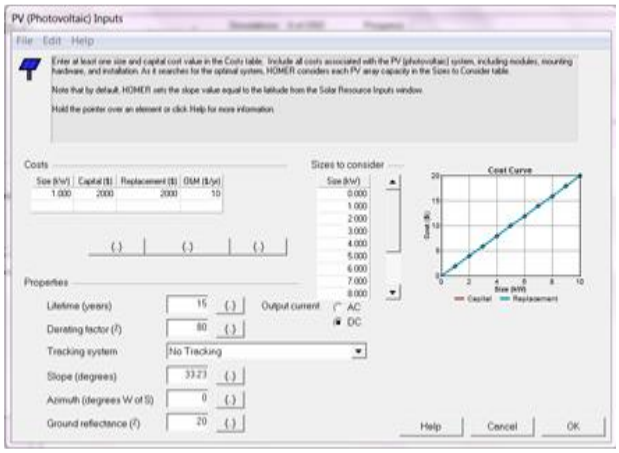

Fig. 4. The PV inputs

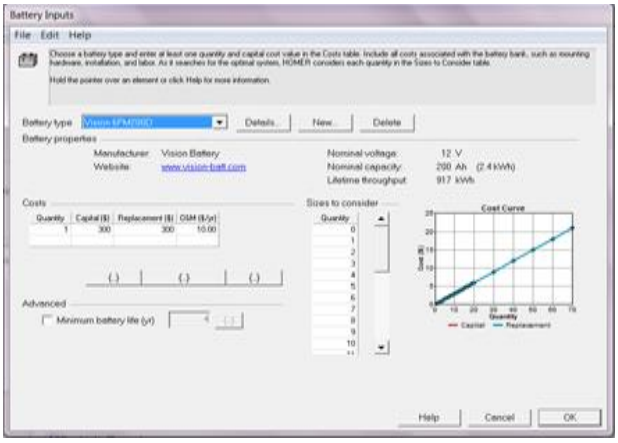

Fig. 5. Batteries input

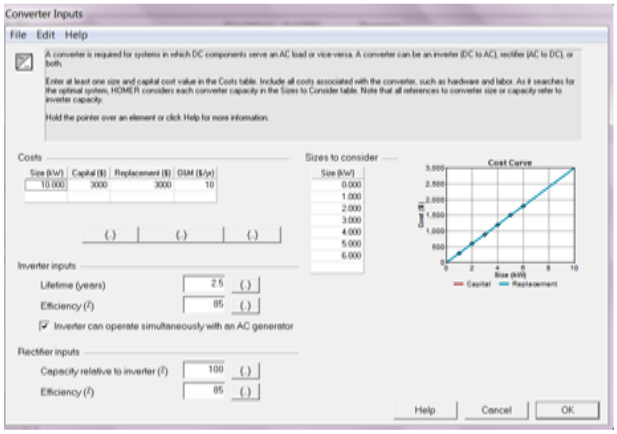

Fig. 6. Converter input

D. Load Data

An average lighting burden was set. The utilization incorporates 10 LED-globule focuses as appeared in Fig. 7. Table 1 shows the sizes of parts of the proposed system, and gives the costs of purchase, replacement, operation, and maintenance. The software, also, determines the system lifetime as inputs to Homer program.

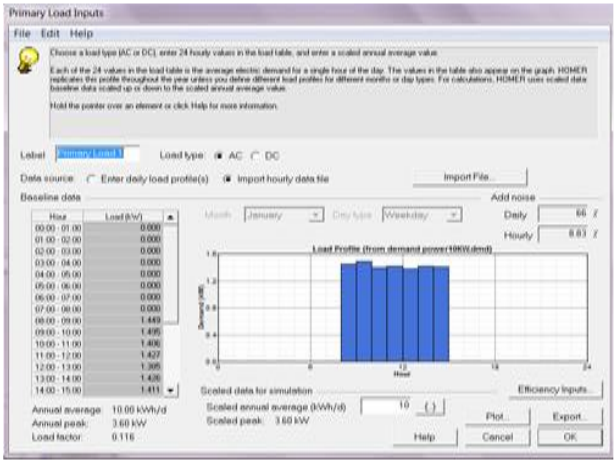

Fig. 7. Primary load input

Table 1, the selected items variable and total costs

Component	Initial Capital ($)	Annualized Capital ($/yr)	Annualized Replacement ($/yr)	Annual O&M ($/yr)	Annual Fuel ($/yr)	Total Annualized ($/yr)
PV Array	16,000	1,647	0	80	0	1,727
Battery	6,000	618	216	200	0	1,034
Converter	1,200	124	408	4	0	535
Totals	23,200	2,389	624	284	0	3,296

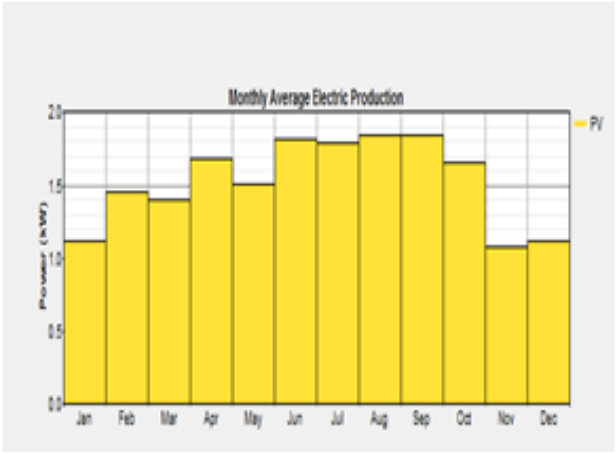

Fig. 8. Monthly average electric production

Fig. 8 indicates to the force era offer of the proposed framework is satisfactory, which make it a decent choice for various applications in Baghdad. This choice is because of reduced productivity of diesel motor and short lifetime. Additionally, an emanation of nursery gasses from the fuel of

same ordinary framework is noteworthy. By adjusting PV innovation, the emission of all these destructive gasses can be considerably lessened.

V. Conclusion

In this study, Homer program was used to design and identify the proposed PV system and its parts to supply The Energy and Renewable Energies Technology Center, University of Technology with the lighting load. Homer software has developed optimized classifications choice for all the system accessories depending on the net present cost. The software calculated all other economic outcomes for the purpose of providing energy to the center. The initial system of nominal cost depends on the size and number of PV panels, and the number and the size of used batteries, also, the transfer capacity as the proposed system is fixed PV panel. PV system performance depends on a range of daily radiation (kW/m2/d) index, and clarity for each month during the year.

The study results showed that the initial cost of the system is up to 23,200 US$, while operating costs are 284 US$/year. The results showed that the number of used batteries for the best store-and- run is 20, when the size of the used converter is 4 kW.

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