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ECONOMIC ANALYSIS OF A SOLAR PHOTOVOLTAIC POWER SYSTEM TO GENERATE ELECTRICITY COMPARING WITH GASOLINE GENERATOR IN THE REPUBLIC OF IRAQ

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ABSTRACT

The economic analysis is very important to evaluate the feasibility of proposed engineering projects for implementation. Most of the generated electricity in Iraq is produced from fossil fuel. The use of fossil fuels has environmental impacts such as greenhouse effect and emission of carbon dioxide CO_2. These sources are expected to be scarce and costly in the coming years. In addition to all these reasons, the problem of the lack of electrical energy supplies in Iraq requires citizens to resort to using solar energy as an alternative and clean source for generating electrical energy.

This paper presents an analysis to investigate the economic feasibility between 2 KW photovoltaic solar power system for generating electricity and traditional source of 2 KW gasoline generator to work in the Iraqi climate conditions. The mathematical model of economic analysis is developed based on proposed model developed by previous researches. The life cycle cost (LCC) and payback period (PP) have been used to investigate the economic viability of the photovoltaic solar system for electricity generation.

The results of an economic analysis indicated that the 2 KW photovoltaic solar power system is very economical compared with 2 KW gasoline generator where, the payback period for the proposed PV solar system is 12 years with the benefits of 3780 $ (4,518,000 IQD) during the lifetime of the system. The results also showed that the life cycle cost (LCC) of the gasoline generator is very high, which it equals to 12110 $ (14,474,000 IQD) compared with the LCC of the PV solar system for power generation, which it equals 6156 $ (7,357,922 IQD). The results of the economic investigation pointed out that the photovoltaic solar system for electricity generation highly economical to work in Iraq.

Key words: economic analysis, solar energy, payback period, life cycle cost, solar photovoltaic power system, Iraq.

1 Introduction

The development of the world, the emergence of modern technology, and the increase in population have led to a significant increase in energy demand in the world and in Iraq in particular. It is known that the increase in energy demand caused an increase in the consumption of fossil fuels, which is expected to be exhausted in the near future [1]. The use of fossil fuels to generate energy has many impacts on the environment such as the greenhouse effect (GHG) that causes an increase in carbon dioxide emissions CO_2 [2]. The renewable energy sources are an appropriate solution to help reduce greenhouse gas emissions. Most of the electricity generated in Iraq comes from fossil fuels. Due to the severe shortage of energy supplies in Iraq resulting from the wars, which caused an increase in government spending on war and reduced spending on infrastructure, especially electricity, where many power plants were destroyed at the time [3]. In 2019, the International Energy Agency (IEA) issued a report on the status of electric power in Iraq, where the agency indicated that Iraq relies heavily on traditional sources and especially on gasoline and diesel generators, where according to the agency's report price of electric energy is the highest in the world, where the price reached to 1250 $ per megawatt hour [4]. Therefore, for sustainable development, renewable energy sources must participate in the electricity market. Solar energy is one of the most important sources of renewable energy in the world and Iraq in particular because of the location of Iraq in the solar belt and the large amount of solar radiation falling in Iraq [5]. The use of alternative solar energy for power generation has become an available and accepted option worldwide. In Iraq solar energy can be considered the best and most logical alternative to burning fossil fuels [6]. Energy saving has positive effects and is very important in the progress of countries and societies and solve major dilemmas such as food, water, health, the environment and education. A sufficient amount of environmentally friendly energy that reduces high air pollution and reduces greenhouse gases is one of the biggest challenges facing the planet today [6]. The renewable solar energy source is used for electric power generation, water heating, heating and air conditioning of residential buildings in various ways and technologies [7,8]. At present the use of photovoltaic solar technology to produce electricity has become known and popularly accepted in Iraq.

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Photovoltaic is the conversion of light into electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon studied in physics, photochemistry, and electrochemistry. A photovoltaic system employs solar panels, each comprising a number of solar cells, which generate electrical power. PV installations may be ground-mounted, rooftop mounted or wall mounted. The mount may be fixed, or use a solar tracker to follow the sun across the sky [9]. The PV system contains beside PV arrays, various wiring, battery charge controller, inverters, and batteries, mounting hardware, combiner boxes and monitoring equipment.

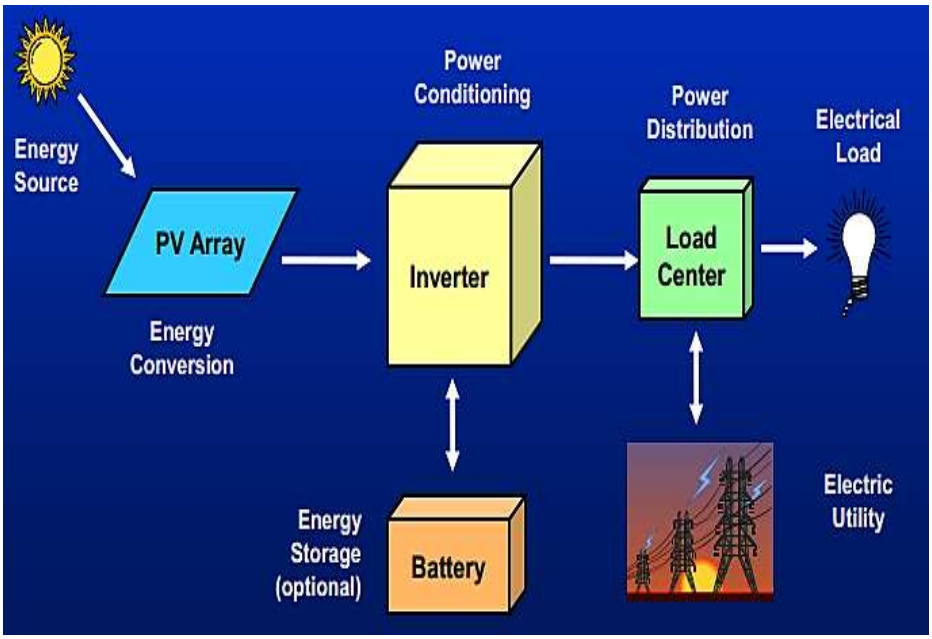

Fig .1. The process of photo-conversion of solar energy into electrical energy.

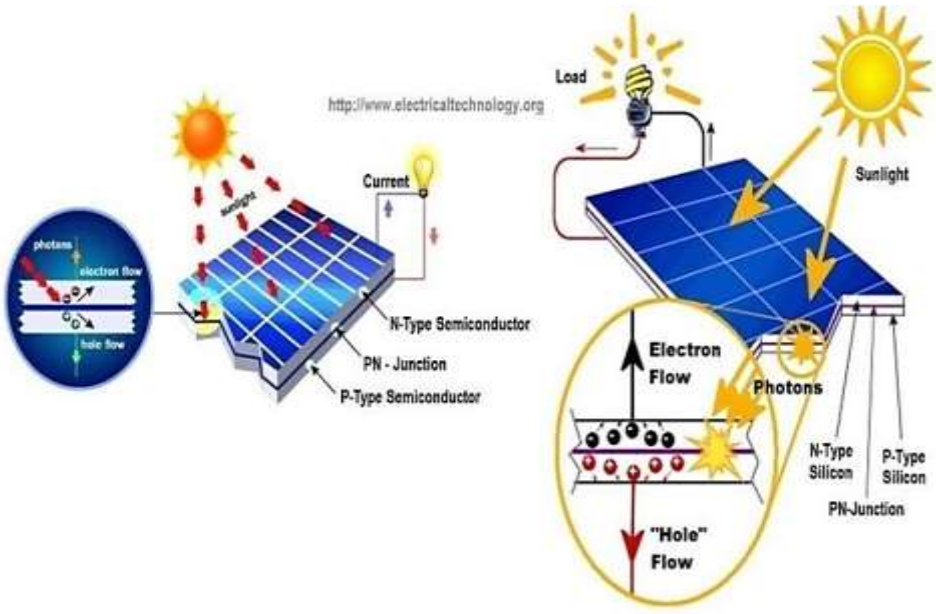

Fig .2. Configuration of photovoltaic power generation system.

2 Economic analysis of the proposed solar systems

The economic feasibility study is of great importance. It identifies any logistical or business problems that the project may face, as well as solutions, and also enables the identification, and organization of the necessary information for the establishment of a project. Feasibility study for any project is very important as it shows the project's ability to achieve the desired objectives. Economic feasibility study for any project is the guide for the investor. Based on the results of the economic feasibility studies, the investor or consumer can see the opportunities available, which deserve further detailed study, and, as a result, provide a level of security for the funds to be invested. There are several methods to study the economic feasibility of investment projects such as life cycle cost (LCC), net present value (NPV), internal rate of return (IRR) and payback period (PP). In this study the method of life cycle cost (LCC) and payback period (PP) are used to evaluate the economic feasibility of proposed solar photovoltaic system.

2.1 Economic analysis of solar photovoltaic system for electricity generation

The payback period is the number of years required to recover the capital invested (cost of investment). Payback period (PP) for photovoltaic solar system can be obtained as in the following equation: [10,11]

$$\mathrm{PP} = \frac{LCC_{PV}}{EC_{PV}} \quad (1)$$

Where, LCC is the life cycle cost of the photovoltaic solar power system, and can be obtained as in the following equation [10]

$$\mathrm{LCC} = \mathrm{C_0} + \mathrm{O\&M} + \mathrm{R} \quad (2)$$

Where, $\mathrm{C_0}$ is the initial capital cost, which is the summation cost of each part of the photovoltaic system i.e. PV array, inverter, storage batteries, electric control and battery charger as well as electric cables, packaging, transportation and installation. O & M are the operation and maintenance costs. R stands for the total replacement cost, which includes the battery replacement over the system lifetime and inverter, charger and wires (BOS).

EC_{PV} represents the cost of energy generated by the photovoltaic solar system, and can be calculated as in the following equation:

$$EC_{PV} = Q \times PE \quad (3)$$

Where, PE is the price of electricity unit generated from the solar photovoltaic system ($/kWh), and Q is the real power generation by PV system (kWh), and calculated as in the following equation:

$$Q_{pv} = 6 \text{ hours } \times 345 \text{ days } \times \text{ power of PV system} \quad (5)$$

Where, the number 6 represents the hours of actual production in each day during the year, and 345 days because a 20 days for the rest and maintenance purposes. Table 1 shows the economic assumptions of the proposed PV system. The benefits from selling the solar energy produced from a 2 kW PV system during a 20 years life cycle can be calculated as in the following equation: [10]

$$\text{Benefits} = EC_{PV} \times 20 - LCC_{PV} \quad (6)$$

Table .1. The economic assumptions of proposed photovoltaic solar system. [11,12]

Parameters	**Assumptions**
Price of electricity	0.12 $/KWh
Price of battery	1.7 $/Ah
Inverter, charger, wires	6% of PV array price
(O & M)	3% of initial cost
Life cycle of the system	20 years
Replacement parameters (R)	BOS each 10 year batteries each 10 year

3 Results and discussion

Table .4. Shows the calculation of the life cycle cost of the proposed photovoltaic solar system.

Cost of solar photovoltaic system	
PV array Cost (2 kW)	= 2000 W × 0.85 $/Wp = 1700 $
Batteries (500Ah)	= 1.7 $/Ah × 500 Ah = 850 $
BOS cost	= 0.06 × 1700 $ = 102 $
Initial cost (C_0) = PV array + Batteries + BOS	= 1700 $ + 850 $ + 102 $ = 2652 $
O & M cost	= 0.03 × 2635 $ = 80 $/Annual
R	BOS = 102 $ per ten years Batteries = 850 $ per ten years
Life cycle cost (LCC) = C_0 + O & M + R	= 2652 + (80× 20) + 2(102+850) = 6156 $
$PP = \frac{6156}{6\times345\times2\times0.12}$ = 12 Years	
Benefit = 9936 – 6156 = 3780 $	

It is well known that high-efficiency energy saving systems (solar systems) is characterized by high initial cost but have significant future benefits for the consumer and the government. It is important to compare the proposed photovoltaic solar system with a gasoline generator because most of Iraqi citizens these days depend on these small generators for generating electricity. Table 5 shows the economic assumptions of the proposed gasoline generator for the feasibility study compared with the proposed photovoltaic solar system.

Table .5. The economic assumptions of gasoline generator compared to the proposed PV solar system [10].

Type of generating system	**Solar PV system**	**gasoline generator**
Power of system	2 kW	2.5 KVA (2KW)
Price of system	6054 $	250 $
Price of fuel	-	0.38 $/litter
Consumption of fuel	-	0.5 liter/hour
Replacement	-	replacement each 2 years
Annual maintenance cost	80 $	70% of initial cost = 175 $
Annual fuel consumption	-	= 0.38×0.5×345× 6=393 $
LCC	20 years	= 250+(250× 2)+(175× 20)+(393× 20) =12110$

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By comparing the proposed PV solar system with the gasoline generator it is clear that the life cycle cost of the gasoline generator is very high twice the proposed PV system that is resulting from the high operating cost i.e. high cost of fuel consumed by the gasoline generator, and high cost of maintenance while the proposed PV solar system characterized by low operation and maintenance cost. Figure 3 shows the life cycle cost of the proposed PV solar system and the gasoline generator.

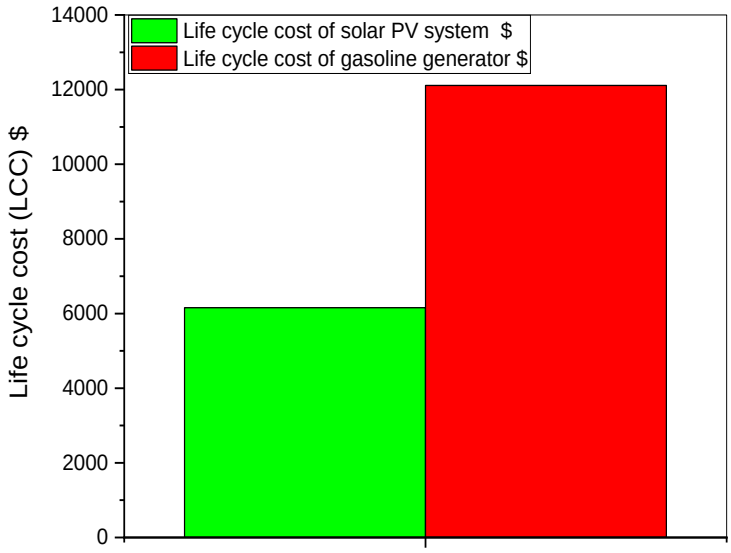

Figure .3. Shows life cycle cost of photovoltaic solar system and gasoline generator.

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Conclusions

In this economic analysis it is concluded that the 2 KW photovoltaic solar system for power generation for residential applications in Iraq is feasible and has a significant role in energy saving and reduction of emissions CO_2. The results showed that the life cycle cost of the proposed PV solar system is 6156 $ (7,357,922 IQD) which its low compared to the gasoline generator, which its life cycle cost is 12110 $ (14,474,000 IQD) i.e. twice the life cycle cost of the proposed PV solar system. Also, the results of the analysis showed that the payback period for the proposed PV solar system is 12 years with the benefits is 3780 $ (4,518,000 IQD) during the lifetime of the system. From the results of the economic analysis of the proposed photovoltaic solar system, it is recommended to use the PV solar system for generating electricity instead of diesel or gasoline generators to operate in Iraqi climate conditions.

References

[1] M.T. Chaichan and K.A.H. Al-Asadi, "Environmental impact assessment of traffic in Oman," International Journal of Scientific & Engineering Research, vol. 6, no. 7, pp. 493 - 496, 2015.

[2] Abedin, A. H. & Rosen, M. A. (2011)." A Critical Review of Thermochemical Energy Storage Systems,". The open Renewable Energy Journal, 4, 42-46.

[3] A. A. Al-Waeely, S.D. Salman, W.K. Abdol-Reza, M.T. Chaichan, H.A. Kazem and H.S.S. Al-Jibori, "Evaluation of the spatial distribution of shared electrical generators and their environmental effects at Al-Sader City-Baghdad-Iraq," International Journal of Engineering & Technology IJET-IJENS, vol. 14, no. 2, pp. 16-23, 2014.

[4] The official website of the International Energy Agency (IEA) 2019 : https://www.iea.org.

[5] A.H. A. Al-Waeli, K. Sopian, H.A. Kazem and M.T. Chaichan ,PV/T (photovoltaic/thermal): Status and future prospects "Renewable and Sustainable Energy Review", vol. 77, pp. 109-130, 2017.

[6] A.H. A. Al-Waeli, K. Sopian, H.A. Kazem and M.T. Chaichan ,Photovoltaic solar thermal (PV/T) collectors past, present and future: A review," International Journal of Applied Engineering Research", vol. 11, no. 22, pp. 1075-10765, 2016.

[7] H.A. Kazem, H.S. Aljibori, F.N. Hasoon and M.T. Chaichan ,Design and testing of solar water heaters with its calculation of energy," Int. J. of Mechanical Computational and Manufacturing Research", vol. 1. No. 2, pp. 62-66, 2012.

[8] M.T. Chaichan, K.I. Abass & H.M. Salih, "Practical investigation for water solar thermal storage system enhancement using sensible and latent heats in Baghdad-Iraq weathers, "Journal of Al-Rafidain University Collage for Science", issue 33, pp. 158-182, 2014.

[9] Lo Piano, Samuele; Mayumi, Kozo (2017). "Toward an integrated assessment of the performance of photovoltaic power stations for electricity generation". Applied Energy. 186 (2): 167–74. doi:10.1016/j.apenergy.2016.05.102.

[10] Muslim, Hasan Noaman, Afaneen Alkhazraji, and Mohammed Ahmed Salih. "Feasibility study of using 2kWp residential PV system comparing with 2.5 kVA gasoline generator (Case study: Baghdad city)." International Journal of Energy and Environment 9.1 (2018): 57-62.

[11] Mohammed Al-Smairan, Rida Al-Adamat, Omar Al-Nhoud, "Techno-Economic Feasibility of Energy Supply of Remote Dump Site in Jordan Badia by Photovoltaic Systems, Diesel Generators and Electrical Grid". Research Journal of Applied Sciences, Engineering and Technology, Volume 4, Issue 9, pp. 1073-1081, May, 2012.

[12] Atse Louwen, Wilfried van Sark, Ruud Schropp, André Faaij, "A Cost Roadmap for Silicon Heterojunction Solar Cells". Solar Energy Materials and Solar Cells, Volume 147, pp. 295-314, April, 2016.

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