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The Feasibility of Using Home Solar Energy Systems and their Importance in Reducing Environmental Pollution in Hilla-Iraq

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ABSTRACT

Man produces the energy he needs in different ways since ancient times, and perhaps this produced energy causes him and his environment great dangers, recently represented by the dangers of global warming and worsening environmental pollution. As a result, many international conferences and seminars were held at the highest levels, which warn of the seriousness of the situation. Effective and urgent solutions must be developed to solve this problem. One of the most prominent proposed solutions that appeared on the horizon was the need to expand investment in clean energy project, Which encouraged researchers, investors and consumers to take advantage of these sources. In recent years, there has been a significant decline in the prices of clean energy sources, especially solar energy. In this paper, the feasibility of using solar energy to supply a house with the necessary electric energy was studied and compared to the consumption of electrical energy for the same house produced from fossil fuels and supplied from the national grid. Through the data obtained from the meteorological station in Hilla, it was found that solar radiation is a catalyst for investment in the field of solar energy in the city of Hilla. Likewise, the spread of such systems on a large scale can benefit the environment and human health in order to reduce the emission of greenhouse gases and pollutants and the environmental pollution associated with energy production by traditional methods.

Introduction

Energy occupies, without a doubt, the important and indispensable part in the formation of economic and social activity in all areas of production, service and distribution. Whether it has advanced or simple technological uses, then energy consumption generates some residues and waste that interfere with the natural ecosystem, causing pollution. With the aspirations of civilized human societies to increase the quantities of energy for industry, trade, transportation, domestic uses, and others, it has become imperative for them to take into account the environmental system in which they live. And to limit the emission of carbon dioxide and substances that deplete the ozone layer, with the aim of protecting the environment and conserving energy for the emerging generations on the one hand, Rationalizing energy, managing demand for it, urging the use of renewable energy and creating new energies that meet the needs of two billion people in the poor world that have not received any service, on the other hand, In particular, hydrocarbon fuels were used equivalent to 7-8% of global energy supplies in 2010, of which oil accounted for 34%, coal 29%, and natural gas 24%. While renewable energy sources contribute 8%, and nuclear energy represents the remaining 5%[1]. As economic planners are not very interested in how to obtain fossil energy sources, as much as they are interested in preserving and rationalizing them, raising their efficiency and searching for renewable sources. Thus, despite the efforts of some Arab countries to adopt strategies to advance the production of renewable energy from its various available sources, To diversify the sources of fossil energy production and limit its depletion, including Iraq, and limit the depletion of financial resources for its purchase, for consuming countries on the one hand, and to prevent the exacerbation of environmental pollution problems resulting from it, on the other hand, However, this interest remains limited due to government support for energy prices, which include a wide range of oil products, electricity, gas... and others. Perhaps it goes without saying that such strategies can be followed directly in Iraq, without adopting supportive policies that contribute to raising the share of renewable energy in it, out of total energy consumption, By raising the efficiency of using fossil energy, rationalizing its consumption and reducing investment in it to limit its excessive growth, as well as adopting substitution policies and allowing the private sector to enter into its production. The study aims to shed light on the possibility of using clean energy sources and their importance in reducing environmental pollution, as well as calculating the economic feasibility of using solar energy in the city of Hilla and in Iraq in general due to the abundance of solar hours throughout the year.

Solar energy system

The solar energy system operates on the basic principles of energy conversion - converting light energy (in the case of a solar photovoltaic system) into electrical energy or converting thermal energy (in the case of a solar thermal energy system), as we can see in Figure(1) [2-5].

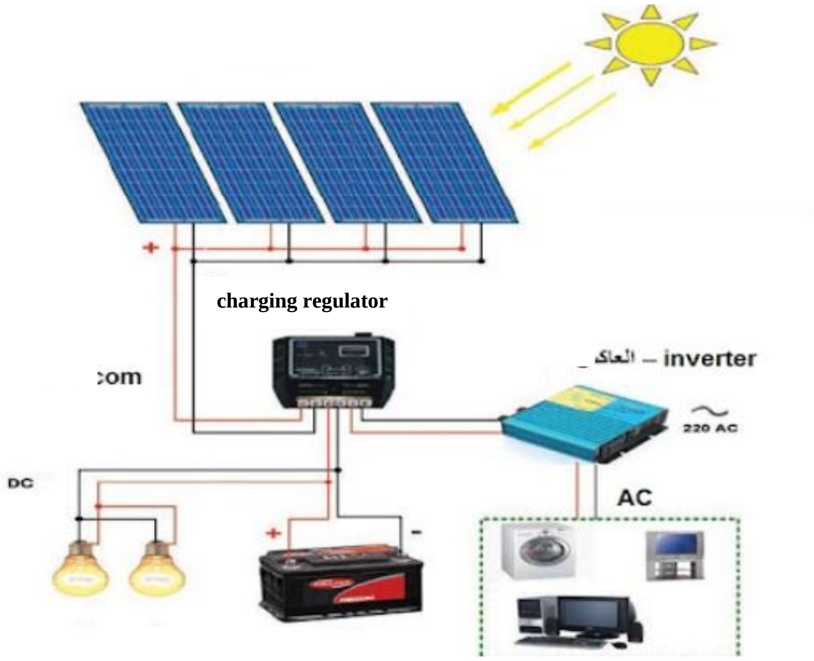

Figure (1): The solar energy system.

A solar PV system consists of several solar PV panels called modules. Each of these panels has photovoltaic cells arranged in a matrix. Each PV cell consists of two layers of semiconductors, usually made of silicon. Each of these layers has different impurities such as boron and phosphorus added to it. When the cell is connected to the positive and negative terminals it forms an electrical circuit and when the light energy falls on the cell, Electrons release from the electron-rich layer of atoms and flow to the electron-minus layer, and so on, an electric field is created between the layers producing a direct current as in Figure(2) [2-5].

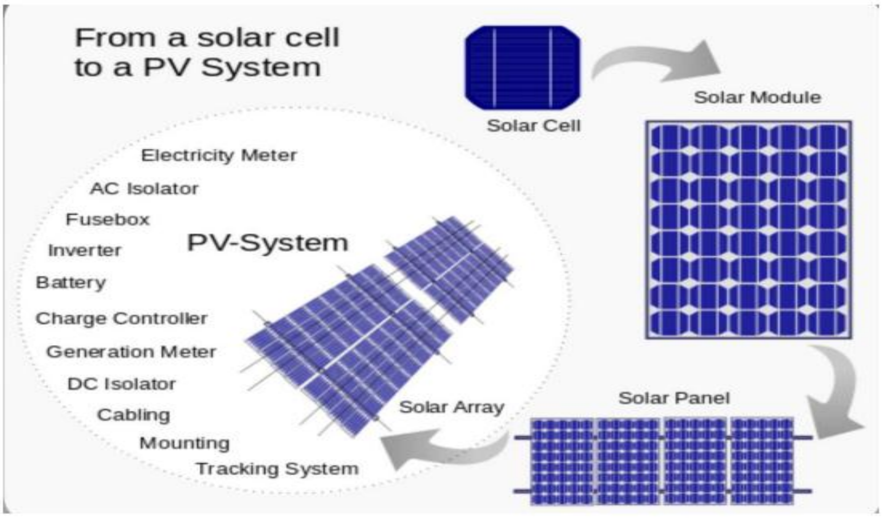

Figure (2): The PV solar cell.

This direct current is converted into alternating current suitable for domestic use using transformers. The current generated from this solar to AC power system is used to power the primary load (equipment and devices). Any excess power generated can be returned to the grid or stored in the battery.

Solar cell interconnection systems:

Due to the intermittent nature of energy in the case of renewable energy, one always needs a main source of energy integrated with the solar system. Thus, solar energy systems are of three types: Stand alone, Grid Connected, and Hybrid.

Standalone: The system is connected to the PV which serves as the primary power source. Grid connected system: The solar system is connected to the grid and synchronized with it. Hybrid system: The system is connected to both the PV group and the network.

The size of a solar power system depends on various factors such as the amount of sunlight the system receives, power consumption or load requirements, and the regulatory policies of the particular state in which the system is located.

Solar cells:

Solar cell technology is used to convert solar radiation directly into electrical energy. This conversion mechanism is known as photovoltaic conversion [6]. It is considered one of the best applications of renewable energy in the field of electricity generation, as it is characterized by limited maintenance and operation costs, and has a lifespan of (20-25) years [7]. They are semi-conductive, optically sensitive pulses, surrounded by an electrically conductive front and back cover, on which many chemical, physical and electrical treatments have been intensively and independently [8]. Solar cells consist of photovoltaic converters made of chemically treated silicon, as they capture the sun's rays falling on their surface, and an electron is liberated from them. These liberated electrons flow into wires connected to the cell, resulting in electrical energy. Solar cells consist of glass thermal panels that are placed at an oblique angle on the surfaces to gain greater An amount of energy connected to electrical wires and connectors with special specifications for transmitting current [9].

Effects of using solar energy on the environment:

Solar energy has a positive impact on the environment as it is environmentally friendly energy that is available, free and renewable. Its source is the sun, which produces clean electric energy that is used in various fields and human activities, whether by installing solar thermal systems or installing photovoltaic panels. Its use helps to reduce dependence on energy produced from fossil fuel sources, which are environmentally harmful and economically costly, and solar energy reduces air pollution and carbon dioxide emissions, thus reducing greenhouse gases [10], They do not cause environmental pollution or noise, as is the case in stations that rely on traditional energy sources to produce electricity, and they can be used for residential sectors as a suitable alternative to electricity and benefit from it to the maximum degree of use at a low and reasonable cost without reaching an expensive bill [11], And then it acts as an insulating roof that prevents heat from reaching the roof when it is placed on the roofs of houses, and thus reduces the intensity of heat.

Case of Study

System description:

The location of the proposed system to be installed for a house in Babel Governorate - Al-Qasim district - Al-Jarbu'iyah area, for a house consisting of two rooms, a reception, a hall, and a health complex, the area of the house is 170 square meters, as shown in Figure (3):

Figure (3): Aerial photo of the proposed house in Babel Governorate - Al-Qasim District - Al-Jarbu'iyah District.

The solar panels proposed to be used in this system are of the MTS brand, polycrystalline, with a capacity of (660) watts. The board specifications are listed in Table (1):

Table (1): Specifications of MTS solar panels

Parameters	.Value	Parameters	.Value
No. of Cells	72(series)	p_{max}	660 (W)
Weight	38.2 kg	Temperature coefficient V_{OC}	- 0.25%(V/^oC)
Dimensions	2384 x 1303 x 35 mm	Temperature coefficient I_{Sc}	+ 0.04%/ ^oC
I_{Sc}	18.42 (A)	Temperature coefficient P_{max}	- 0.34%/^oC
V_{OC}	45.89(V)	Module efficiency	21.2%
I_{mp}	17.34(A)	NOCT	43±2(^oC)
V_{mp}	38.08(V)	Type of cell	pc-Si

Energy production estimate:

The power produced (max) P by solar cells can be calculated from the following relationship [12-13]:

$P_{max}= V_{max}.I_{max}$ …………………..(1)

Conversion efficiency is calculated as the ratio of maximum power produced to incident power in the solar cell area from the equation[14]:

$$\eta_{elec} = \frac{p_{max}}{A\,G_T} \times \%100 \text{..(2)}$$

Where (A) is the area of the cells, (GT) is the total solar radiation.

The required capacity of the photovoltaic system (E_r) should be the daily power demand of the house (D) plus the expected system losses (L_s). It can be assumed that system losses are about 30% of the total the demand for that[15].

$$E_r = (D * L_s) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Total Peak Rating Watts (w_p) of PV Panel Capacity Required:

$w_p = E_r / 5.27$ ....(4)

Where 5.27 is the panel generation factor (the daily solar radiation of the test case radiation standard for PV panels).

$No_{modules}$ for the current system depends on the w_p of the solar panels[16]:

$No_{modules} = w_p / P_{max}$..........(5)

The battery must be large enough to store enough energy to power the devices at night and on cloudy days. Therefore, the solar energy per day must be sufficient for the requirements of the house. Battery specifications are shown in Table (2):

Table (2): Battery specifications

Nominal Voltage (V_b)	48.0 V	Battery Efficiency(μ_b)	90.0%
Depth of Discharge (DOD)	40.0%	Life of a Battery (B_L)	4 years
Battery Capacity (C_b)	200.0 Ah		

Required battery capacity (Cr).

$$C_r = \frac{(D) * \text{Days of Autonomy}}{V_b * (1 - DOD) * \mu_b} \text{...........(6)}$$

The capacity of each battery determines the total number of batteries:

No. of Batteries $= C_r / C_b$ ....(7)

The system inverter size $C_{(inv)}$ depends on the peak watt requirement. The inverter must be more than the maximum power requirement. That is to say, the size of the inverter is at least 25%-30% higher than the total load connected;

$C_{inv} = w_p * 1.3$. ....(8)

Determines the number of system inverter $No._{inv}$ using the rated power of the inverter which is about 20kW.

$No._{inv} = C_{inv} / W_{inv}$...........(9)

Modern smart transformers have the ability to cut off the current surge, so you do not need an inverter with a capacity of more than (w_p), but the large capacity of the transformers is useful for future expansion.

The number of panels to be connected in series Z_{array} depends on the inverter voltage Voc and the panel voltage Voc.

$Z_{array} = V_{oc\ inverter} / V_{oc\ module}$ ....(10)

Where the $V_{oc\ inverter}$ is equal to (600 V DC), the number of rows in the solar system No_{arreys} is calculated from the relationship:

$$No_m / Z_{array} = \text{No of arrays.} \ldots\ldots\ldots\ldots(11)$$

Maximum voltage input to the inverter = $(V_{max\ module}) * (Z_{array})$ ....(12)

The total area of the solar energy system ($A_{modules}$)[17].

$A_{modules} = No_{modules} * L_{module} * W_{module}$ ....(13)

Where L_{module} and W_{module} are the length and width of the solar panel respectively.

Total energy produced by the solar system in a year (E_g)

$E_g = D * 329.6$ day/year

As 329.6 day/year is the number of sunny days in a year.

The space required for the system depends on the layout and arrangement of the panels.

The number of panels in the matrix is 15 panels arranged in six matrices. The width of the solar field is the same as the width of the array (15m). The ratio of ground cover to slabs, assuming about 0.5m, will be the distance between the two successive rows

$= 1.995 * 2 \approx 4$ m

length of the system field = 4 ∗ No of arrays

Area of the system required = Z_{array} ∗ length of the system field

The carbon dioxide emission rate from electricity generation is 0.707 kg CO2 per kWh [18],

Carbon dioxide emission mitigation is the amount of carbon dioxide emissions reduced by power generation from the photovoltaic system, carbon dioxide emissions are reduced annually Calculate: $= Eg * 0.707$

The distinction between CO_2 emissions and CO_2 mitigation over the life of the system, i.e. 30 years, is equal to the net CO_2 mitigation of the system. It

is calculated using the relationship:

Net CO_2 Mitigation = (Yearly CO_2 Mitigation ∗ 30year) − (CO_2 Emissions)… …(15)

Electricity tariff:

The electricity tariff supplied to the domestic sector, which is the largest consumer of electricity by 59%, is subsidized by the government by 93%, and the government subsidizes the price of one kilowatt of electricity supplied by the Iraqi citizen. (1-1500, 1501-3000, 3001-4000 and 4000+) kWh (0.0083, 0.029, 0.066, 0.1) $/kWh [15]. The electricity tariff with government subsidies is one of the cheapest electricity rates in the region.

-Calculate the energy required to equip the house:

To calculate the energy required to equip the house consisting of two rooms, a reception, a hall, a kitchen and a health complex, with the supplied electrical energy. Details of the in-house equipment are listed in Table (3). The table also contains the daily energy demand required by the solar photovoltaic system.

Table (3): Appliances and equipment contained in the house and the daily demand for electrical energy

Annual consumption (W)	Number of months of operation	monthly consumption (W)	daily consumption	hourly consumption (W)	Daytime operating hours	operating hours at night	Ability	No.	Device type
1209600	12	100800	3360	280	4	8	20	14	lamp(1)
1382400	12	115200	3840	320	4	8	40	8	lamp(2)
129600	12	10800	360	30	4	8	15	2	lamp(3)
1101600	12	91800	3060	255	4	8	85	3	lamp(4)
10713600	12	892800	29760	1240	12	12	1240	1	frozen
3024000	6	504000	16800	1200	6	8	1200	1	air conditioner
672000	8	84000	2800	200	6	8	50	4	Fan(1)
403200	8	50400	1680	120	6	8	60	2	Fan(2)
432000	6	72000	2400	100	6	12	100	1	heater
1166400	12	97200	3240	135	12	12	135	1	refrigerator
1080000	12	90000	7200	300	4	6	150	2	television
21314.4Kw			74.5 Kw	4.18 Kw					the total

Financial evaluation of the system:

The cost of photovoltaic solar energy in the Iraqi market is $1/watt without batteries. The cost of four batteries (12 volts) is $200, and the cost of the rack is ($5). After the operating time, the system needs annual maintenance and management costs (0.1%) of the investment cost and equipment replacement (1% of PV panels annually, inverters every five to six years and batteries every four years) [18].

RESULTS DISCUSSION

Full details related to the proposed system are shown in Table (4).

Table (4): Details of the proposed system

Daily demand(D)	74.5 Kw kWh/day
Total watt peak rating (w_p)	22 kW
No. of modules($No_{modules}$)	34(660W)
Total area of modules	106 m^2
No of batteries	4(48V)(200Ah)
No of modules in panel	11 modules
No of array	3 arry
No of invertor	2(20 kW)
Cost of Batteries	1080$.
Net CO_2 Mitigation	499458.2 kg
Total cost without the land	13096$.

Using the PV-Syst simulation program, the amount of incident solar radiation at an inclination angle of 15 o is about 1964.1 MWh. The monthly solar radiation and temperature in the city of Hilla are shown in Figure (4):

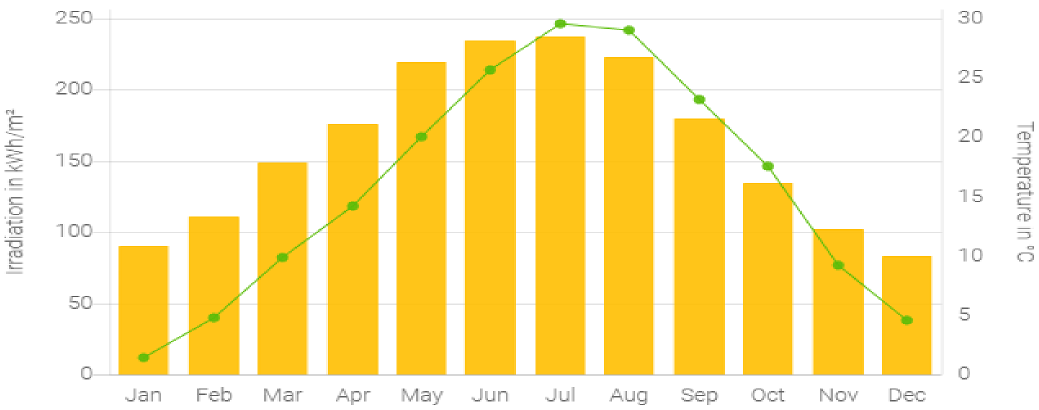

Figure (4): Average monthly solar radiation and temperature in Hilla city From Figure (4), we notice that the solar radiation available in the city of Hilla is a catalyst for the use of solar cell systems throughout the year.

No high load of AC and fans is required during winter season (October-May) resulting in low energy consumption. In the summer, an increase in temperature leads to a decrease in the energy output, while at the same time increasing the amount of solar radiation. Total losses in solar energy production are 17.2%. Figure (5) shows all sources of energy loss in the system. But these losses can be eliminated by using a cooling system to cool the panels. As well as coating the solar panels with nano-material to expel dust. Thus recovering losses at the lowest cost.

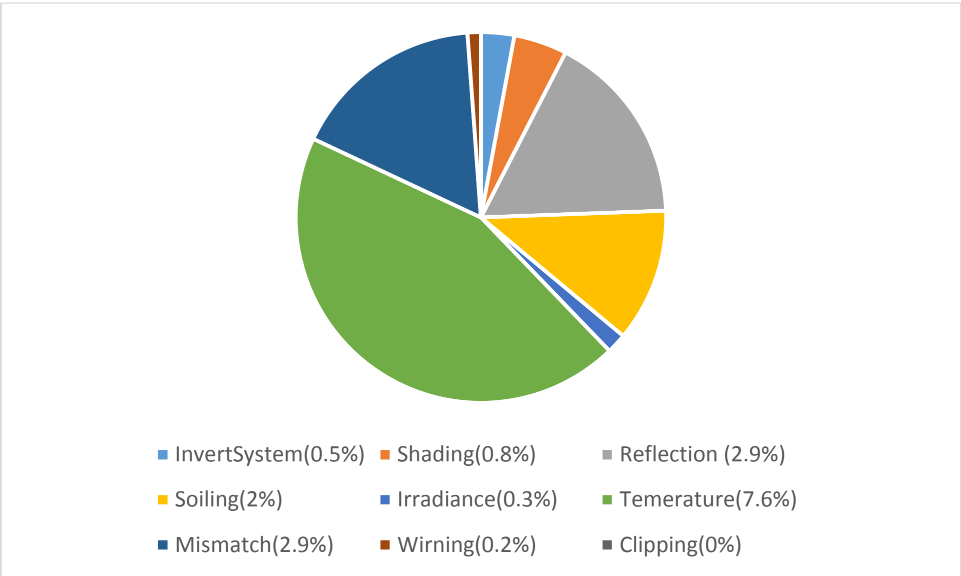

Figure (5): Total system losses.

Using the meteorological data of the city of Hilla and the percentage of daily losses, it is shown in Figure (6) the actual average output energy efficiency of the system is about 14.2%, and the output capacity of 106m^2 of units of the proposed system.

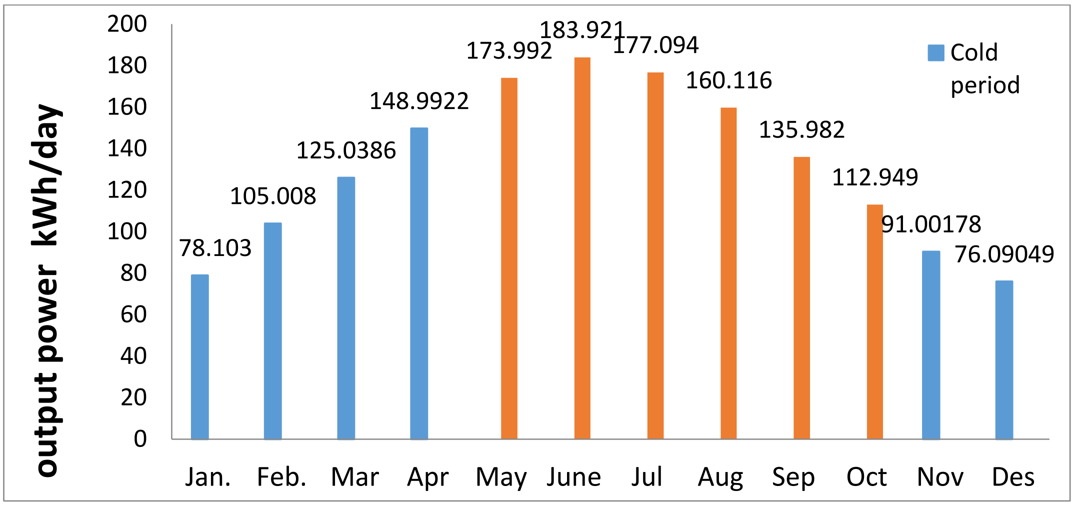

Figure (6): The average productive capacity of the system for each month.

From the figure, we notice that the best productivity of the system is compatible with the maximum energy need in the months of May, June and July.

The annual production of the system was 47917.67 kWh/year with an efficiency of 14.2 which is greater than the proposed method. The margin between the maximum demand and the capacity of the system is 91 kW / h / day, and it is sufficient to compensate for the shortage in the early morning and at the end of the day. When these systems are used on a larger scale, we notice that productivity will increase, and this can be represented by Figure (7).

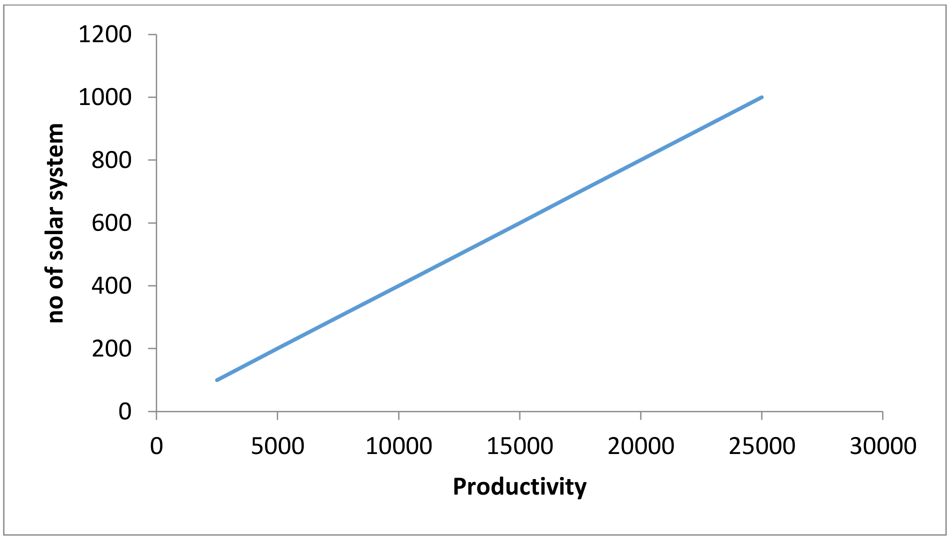

Figure (7): Productivity of 1000 solar systems.

Figure (7) represents the productivity of (1000) a system with a capacity of 22 kilowatts. The production is (22,000) kilowatts / year, and for a period of (30) years, the production is (660,000). This indicates the feasibility of using solar energy to produce electricity.

The mitigation of carbon dioxide emission is shown in Figure (8), and it is related to the amount of daily energy production.

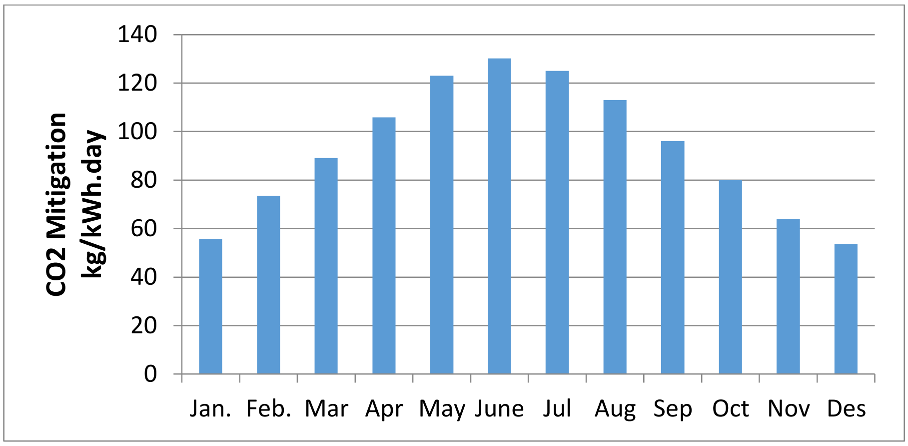

Figure (8): The average mitigation of CO_2 emission.

The wide spread of these solar systems has multiple environmental and economic benefits, the most important of which is the reduction of carbon dioxide emissions in large quantities annually throughout their lifespan, as shown in Figure (9), which represents the amount of carbon dioxide withheld. Using 1000 systems for 25 years.

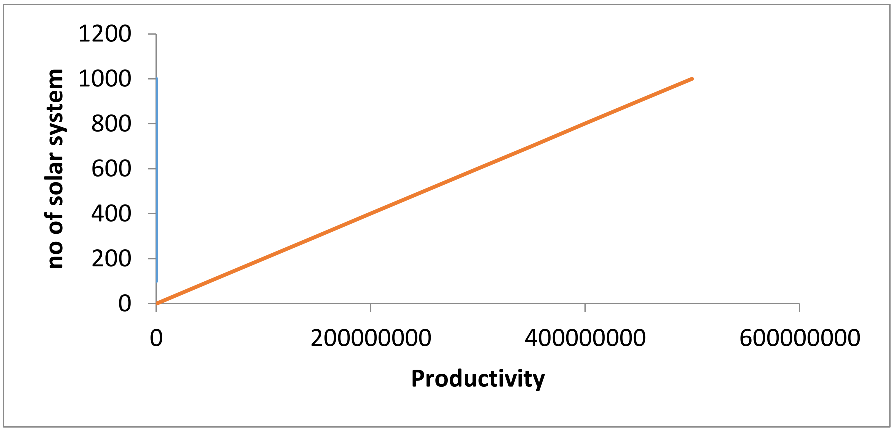

Figure (9): The annual reduction of carbon dioxide for 1000 systems and their lifespan.

The cost of electrical energy consumed annually for the proposed house from the national grid at the government-subsidized tariff rate is (497,336) dollars annually. And for a period of 30 years, the default life of the solar system, the cost becomes (14,920.08) dollars. It is more than the proposed solar system cost price by about 22% of the total cost. Not to mention the environmental and health benefits associated with using a solar system. It is also possible to reduce the cost more than this percentage by resorting to the use of the solar heater to provide hot water for domestic consumption in peak seasons. Therefore, from the results calculated taking into account the environmental, health and economic advantages of solar systems, We see the feasibility of using such systems on a large scale to reduce the environmental, economic and health risks associated with energy production by traditional methods. We note the level of solar radiation and the amount of production, despite the low efficiency of the solar system, the economic feasibility of these systems is stimulating.

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