International Information and Engineering Technology Association
Advancing the World of Information and Engineering

International Journal of Heat and Technology
Vol. 42, No. 4, August, 2024, pp. 1270-1278
Journal homepage: http://iieta.org/journals/ijht

Numerical Study of the Potential of Operation the Direct Driven Solar Air Conditioner with PV Cells in Iraq's Weather

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https://doi.org/10.18280/ijht.420417

Received: 7 May 2024
Revised: 10 July 2024
Accepted: 22 July 2024
Available online: 31 August 2024

Keywords:
performance, solar energy, coefficient of performance (COP), remote areas, climatic conditions, solar AC

ABSTRACT

A numerical study was carried out to assess the practicality of running inverter air conditioner directly on photovoltaic cells in the climatic conditions of Iraq. The research aims to assess the energy consumption and efficiency Regarding the solar air conditioning system in various weather conditions and operational situations. The study employs a computational model to replicate the system's behavior and enhance its performance. Where solar panels with a capacity of 570 watts the number of solar panels 4 were used, the number of batteries 2, and inverter capacity 3.5 kw , the number of panels, and the amount of energy consumed during different time periods and for different air conditioner loads were used, such as one ton, one quarter ton, one half ton, and two tons. Solar panels' lifespan is determined by the extremes in temperature they are exposed to, whereas their output capacity is determined by the amount of light radiation they receive. The amount of batteries, the number of panels, and the kind of inverter required are all determined numerically in this study. The aim of the study was to estimate the efficiency of the air conditioning system, which It runs on solar energy.

1. INTRODUCTION

A decade ago, there was a significant surge in energy usage for cooling purposes in Iraq. The primary factors contributing to the rising the energy demand for summer air-conditioning is influenced by factors such as population growth and improved living standards, greater comfort expectations, and architectural design. This escalating demand represents a major financial burden for homes in Iraq throughout the summer season. Iraq a highly revered location, experiences a predominantly sunny climate, this leads to a significant need to provide cooling during sweltering summer days. Nevertheless, here is a potential for the electrical grid to become overwhelmed as a result of the widespread utilization of air conditioners. This excessive burden presents a danger to crucial services and has the potential to lead to significant economic repercussions. Solar air conditioning refers to a restricted range of choices available to address the increased demand during summer and efficiently handle peak loads [1]. It achieves this while minimizing its negative impact on the environment. In isolated Iraqi communities, located distant from established infrastructure, electrical power is typically provided through the use of diesel generators. Typically, the cost of diesel fuel in these situations becomes too high. Utilizing solar energy for air conditioning has the potential to decrease the reliance on electricity. This study primarily focuses on the design and construction of a solar-powered air conditioning system integrated with a photovoltaic (PV) system. According to the solar radiation map shown in Figure 1 [2]. There are many researchers in literature tried to study the solar air conditioning systems [3].

There are many researchers in literature tried to study the solar air conditioning systems.

In a study conducted by Rahman Shahzad et al. [4], a numerical investigation was performed utilizing an absorption-evacuated tube solar system. The carrier medium employed in this system was a refrigerant of the R410A type. The research was carried out in the climatic circumstances of a city in Pakistan, situated at a latitude of 31.58 and a longitude of 74.32. The investigation was done from mid-June to the height of summer heat, during which the average collector outlet temperature value of 78℃ was recorded throughout the week. This data was collected over the trial period from 3961 to 4129 hours. The solar collector of the EGT type received energy, enabling it to achieve a temperature of 199 degrees Celsius and produce a heat output of 71.065 kilojoules per hour. The water tank, on the other hand, maintained a temperature of 92 degrees Celsius. The temperatures of the three rooms were measured and recorded as 19℃, 27℃, and 30℃, respectively. The implementation of the process and the construction of the system were carried out by the TRNSYS program. The cooling capacity required was 22 kW/h, while the cooling pump capacity was 4 kW/h. The storage capacity reached 41 kW/h, and the temperature achieved for hot water was 115℃. The liquid was conveyed from the tanks to the solar collector and subsequently transported to the absorption system to facilitate the cooling process and acquire the necessary cooling energy for the three rooms.

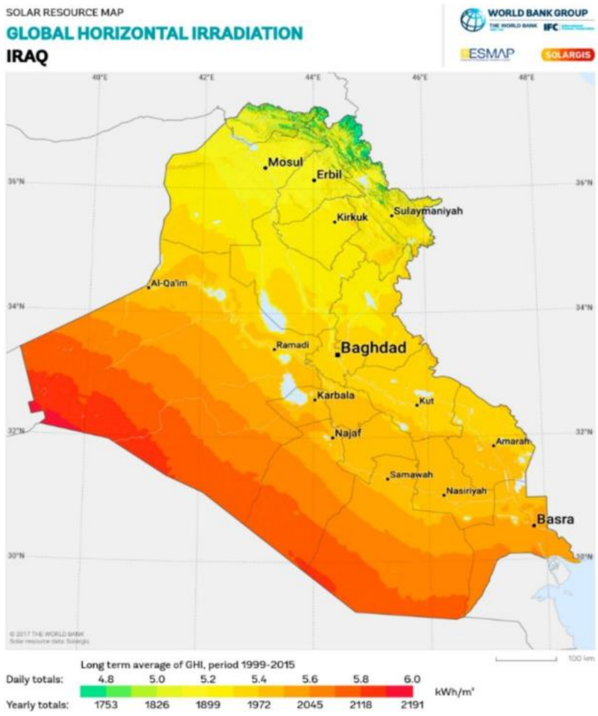

Figure 1. Solar radiation map for Iraq [2]

An numerical investigation by Kumar et al. [5] study confirmed the need to advance the construction of solar-powered structures as a strategy to attain energy self-sufficiency and advocate for more environmentally friendly energy sources. This statement underscores the viability of solar thermal energy in residential applications and the fundamental principles governing solar buildings, namely the collection, storage, and distribution of solar energy.

The article also highlights the substantial upfront expenses of installing solar – powered structures, underscoring their advantages and the significance of cost-effective, easily attainable, and ecologically sustainable energy sources for prospective economic development.

A numerical and experimental study was conducted to assess the viability of using low-GWP refrigerants in an off-grid air conditioning unit [6]. Then, simulation analysis and experimental activities were conducted using a single-stage VCC motor operated mechanically and at various condensing temperatures to determine the most efficient and optimal refrigerants. The evaluation took performance into account. Active and vivacious operation of the mechanically driven air conditioning unit under various cycle conditions. Two 400-watt photovoltaic panels and storage batteries were used to power the system. R250 and R600 demonstrated their suitability as alternatives to traditional refrigerants compared to R 134, resulting in a relative improvement of 2.42% in cop when R290 was accompanied by R250 and R600. This enhancement reduces inputs by 2.31 percent and increases output by 37.2 percent.

Huang et al. [7] studied a total of six solar air conditioning systems, each equipped with varying sizes of photovoltaic (PV) panels and air conditioners The primary objective of their experimental study was to examine the operational feasibility of air conditioning under varied levels of sun irradiation. The experiment was carried out over two months, specifically June and February, with each session lasting eight hours. The impact of the design parameter is the ratio between the maximum power generated by photovoltaic (PV) systems and the power used by the load, on the instantaneous operation probability (OPB) and runtime fraction (R) of the air conditioner, has been demonstrated. The observed performance boundary (OPB) exceeds 0.98 when the instantaneous solar irradiation exceeds 600 W/m², and the ratio of 1.71 R approaches 10, showing that the air conditioner functions solely on solar power.

Opoku et al. [8] investigated the performance of a solar-powered hybrid air conditioning system designed for cooling office spaces during the daytime in hot and humid climates. Their research focused on a specific case study in Kumasi City, Ghana. The study was conducted in a typical office space measuring 30 m² within a building. Neighboring offices surrounded the office on three sides, while the front side faced north. The air-conditioning system was adjusted to maintain a temperature of 20 degrees Celsius. The experiment consisted of configuring the pure sine wave hybrid inverter equipped with an integrated PWM charge control mechanism. Prioritizing solar energy and supplementing it with utility grid electricity when solar production is inadequate is recommended. Their research findings indicated that a solar photovoltaic (PV) system with a power output of 1040 WP and a battery configuration of 200 Ab and 24 V is suitable for daytime cooling in office settings. The system exhibits a monthly average solar fraction of 51%, with a 9% deviation. The air-conditioner used in this setup has the cooling system has a nominal capacity of 25 kilowatts and a maximum power usage of roughly 1.19 kilowatts. The annual energy output of the 1040 WP solar photovoltaic (PV) system has been determined to be approximately 1211 kilowatt-hours (kWh). The financial research suggests that the hybrid solar PV grid-powered air-conditioner has the capacity to save US$ 1600 within a year, as opposed to using 100% utility grid electricity. Based on the from the data that is now available, it has been estimated that running an air conditioner during the day using solely solar energy might save around $3,300 over a ten-year period, in comparison to using only electricity from the utility grid.

Jani [9] sequent, the findings were compared to the results of other research carried out in the identical region. Fluid drying and dehumidifying technology has been introduced as an enhanced alternative to conventional systems like HVAC and VCR, which rely on vapor pressure. These systems are particularly well suited for hot and humid environments, particularly tropical ones, because of their effective management of air humidity. To improve the management of the necessary cooling load, it is advisable to minimize the use of chlorofluorocarbon (CFC) cooling systems due to their inherent toxicity and severe environmental consequences. The primary objective is to enhance the utilization of thermal energy generated by renewable solar radiation while reducing the consumption of electrical energy.

Hussein et al. [10] carried out an experiment in Iraq at the Taji site, located at a longitude of 44.34 and a latitude of 33.432. During the summer, research and development activities were conducted on a solar-powered air conditioning system within an enclosed space; utilizing a payment mechanism—pulse width modulation (PWM) in direct current (DC) air-cooling systems. The examination was administered between the hours of 11:30 AM and 5:00 PM. The duration of radiation exposure amounts to around 12.6 hours. The installation of a photoelectric air-conditioning system took place in June within a chamber of 12 meters situated at the Al-

Taji location. The suggested system utilizes a configuration consisting of panels and four batteries. The efficacy of the air conditioner has been empirically demonstrated in Iraqi environments characterized by high electricity consumption. The utilization of solar energy cools the entire space.

Chen et al. [11] Studied experimentally the construction of a set of parameters for photovoltaic alternating current (PV AC) systems. The factors under consideration are photovoltaic (PV) capacity, alternating current (AC) parameter, and inverter parameter. Subsequently, the parameters were implemented on a 20-meter scale. Two office buildings and a photovoltaic air conditioning system test platform were constructed. The duration of the test spanned one year, during which data was gathered and analyzed. This included both daily data and annual data. According to their research, a photovoltaic air conditioning (PV AC) system may effectively lower or raise a room's temperature by about 9.5% and 17%, respectively, over the course of an hour. The system can successfully control the room temperature to within the target range of ± 0.9°C because of this.

Harishankar et al. [12] Conducted supplementary experiments to develop a solar air conditioning system that utilizes direct current (DC) and depends on a Peltier module. The primary objective of the system is to offer eco-friendly cooling while simultaneously identifying novel applications for waste heat. The intended demographic for this product's design is individuals residing in remote places lacking electricity infrastructure. Their study discussed the utilization of a 12V and 40Ah induction transformer and a step-down transformer within the apparatus. Additionally, the device incorporates an aluminum-wound coil as a cost-saving measure instead of the conventional use of copper. The experiment employs the Peltier effect, in which an electric current is passed through a conductor to generate a temperature difference. The TEC1-12706 Peltier module is used, and the Peltier effect is elucidated about the migration of electrons and holes within semiconductor materials. The report additionally discusses the merits of the thermoelectric module, highlighting its ability to function as both a cooler and a heater due to its reversible direction of the thermoelectric heating pump achieved by altering current polarity.

A numerical study was done by Aguilar et al. [13] This work introduces a computer model that was developed to replicate the functioning of a photovoltaic-assisted heat pump under various geographical locations and operating conditions. Furthermore, this approach has improved the efficiency of a solar on-grid air conditioning system. The model presented in this work has been verified using experimental data obtained across an entire summer (surpassing).

A numerical study was provided by Martinez-Barbosa et al. [14] Described the methodology for mathematically simulating and creating control systems for the compressor motor of an air conditioning unit. The focus is on utilizing energy from a solar system in conjunction with the power grid in a DC microgrid. The complete model takes into account the interconnectedness of several components, including the solar cells, the accompanying DC/DC converter, the DC bus, the three-phase squirrel-cage induction motor, its driver, the bidirectional DC/AC converter, the output filter, and the power grid. According to their analysis, there is currently no existing comprehensive mathematical model for the recommended system. Hence, the mathematical model of the system is assessed and confirmed through simulation using a block diagram in the Matlab/Simulink framework. Furthermore, the overall design integrates various control techniques to effectively supervise and enhance the maximum power output of the photovoltaic cells, guarantee a seamless initiation of the machine, regulate the speed using a variable frequency drive, stabilize the DC bus voltage, and efficiently handle the power transfer between the DC bus and the power grid.

This paper provides a comprehensive description of the solar-powered air conditioning system design and aims to analyze its performance throughout an entire cooling season. The system utilizes PV panels to generate the required power for a small-scale air conditioning system with a capacity of approximately 1 TR. The objective is to compare the performance of this system with that of a conventional system.

2. SYSTEM COMPONENTS

The system under consideration, shown in Figure 2 consists of the following component.

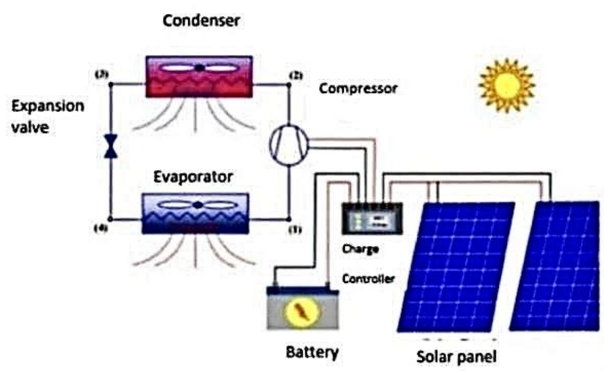

Figure 2. The proposed system's schematic includes the power source, energy storage, and VCC

2.1 Inverter air conditioner

Split-type variable speed (inverter-type) air conditioners were considered the most advanced technology in Europe. Variable speed or inverter air conditioners are more efficient when operating at partial load compared to traditional constant speed air conditioners cooling a load below their rated capacity [15]. The efficiency gain is greatest when they operate under part load conditions. Inverter air conditioners can maintain a more consistent temperature, enhancing thermal comfort. They have the ability to first lower the temperature of a warm space. Quicker to an optimal temperature. They have higher energy efficiency. An inverter AC's primary drawbacks are its elevated initial cost in comparison to a standard AC. Electronic components and control circuitry in inverters are more complex than in non-inverter types, resulting in higher costs for the AC units. A controversial assertion has been made about the impact of inverter air conditioners on the power quality of low-voltage distribution networks [16].

2.2 Solar PV cell

A photovoltaic system is a collection of components specifically intended to generate and provide usable electrical power for various applications [17].

The sun transfers its energy to people predominantly through two mediums: thermal energy and electromagnetic radiation in the form of light. Solar power systems can be divided into two main categories: solar thermal systems, which use sunshine to generate heat, and solar PV systems, which directly convert sunlight into electricity. An. Photovoltaic cells consist of layers of semiconductor material, often silicon.

When light illuminates the cell, it generates an electric field spanning across the layers. Greater solar radiation results in increased electricity generation. Clusters of cells are assembled into panels or modules, which can be installed on the roof. Understanding the peak sun hour is crucial for determining the required quantity of PV modules for installation. Before proceeding, it is necessary to ascertain the power that may be anticipated to be generated by the PV modules, which is contingent upon the solar irradiation at the specific location [18].

2.3 Batteries

The battery is an essential and indispensable component. Batteries are used in photovoltaic (PV) systems to provide energy backup and ensure the continuous functioning of renewable energy systems. The overall battery capacity is measured in ampere-hours (Ah). Furthermore, it functions as a method of storing electricity generated by photovoltaic systems to be utilized during times of cloudy weather and nightfall. In order to apply this system to an AC load, the inverter must be used to transform the DC electricity generated by the PV panel into AC. The AC load is a commonly utilized and easily accessible type of load that is quite affordable [19].

2.4 Charge controller

The charge controller serves the aim of regulating the purpose of the current from the PV module is to safeguard the batteries from overcharging. A charge controller is employed to detect the state of full charge in the batteries and subsequently regulate or reduce the flow of electric current to the battery [20]. The PV module receives solar energy and converts it into electrical energy. The electrical energy is subsequently managed through charge control.

2.5 Inverter

The inverter is responsible for managing the energy tasks, Convert direct current from photovoltaic module to alternating current. Minimize fluctuations in voltage Ensure that the AC waveform's state is appropriate for the application. Many grid-tied inverters can be installed externally, whereas most off-grid inverters lack weather resistance. There are two main categories of grid intelligent inverters: those intended for battery use and those for systems without battery-connected inverters, offering strong grid-quality performance [21].

3. MATHEMATICAL MODEL CALCULATION

The coefficient of air conditioner can be described [22].

$$COPcooling=Desiredoutput/Inputpower \tag{1}$$

The amount of energy consumed per day can calculated be by applying the following equations [11, 23-25]:

The energy that the devices consumes per day= Number × device capacity × working hours (2)

The loss during installation and it is approximately equal to = 30%. Naturally, there is a loss during the installation of any electrical system, and the loss may reach 30% due to the loss in the connections, the quality of the wires, the resistance of the batteries used, as well as the efficiency of the solar panels. Accordingly, this total loss must be added to the energy consumed per day by applying the following equation:

Total energy required = Total energy consumed per day × 1.3. (3)

Calculating the number of solar panels: by Knowledge Energy of solar panels. The energy to be generated must be divided by the rate of solar radiation per day for the area in which the panels will be installed, which is between 4 and 6.3 kwh/m^2 [23], which is one of the highest rates in the world, as in Iraq. the rate of solar radiation per day for the Thi-Qar (5.6) kwh/m^2 as shown in Figure 1 Panels with a capacity of 570 watt were selected.

Energy of the panels needed = energy to be generated / rate of solar radiation per day (4)

No. panel = power of the panels needed / capacity of the panel we want to buy. (5)

Calculate the number of batteries.

Battery capacity (Amp per hour) = {Power to be generated x Number of cloudy (days during which the panels will be interrupted) × 1.3 / voltage. (It is necessary to keep 30% of the capacity batteries to keep it) (6)

To find out the number of batteries, apply the following relationship:

Number of batteries = Batteries capacity / Size of battery to be purchased. (7)

Size of solar regulator: It is calculated as follows.

The number of panels planned to be installed in the system × Isc (the highest charging ampere for the panel). (8)

It is preferable to double the size as a precaution in the future, if we want to expand the system to work for a longer time or the Add other devices.

3.1 Economic analysis

Iraq is widely recognized as a nation grappling with challenges about electricity generation. Many individuals have encountered power outages, which have a direct impact on their daily lives and the well-being of individuals. These outages result in the interruption of heating and cooling systems in residential and commercial structures, particularly during the hot summer months. One of the essential strategies for addressing power outages is the utilization of renewable energy sources, particularly solar energy, to power cooling devices. The present study focuses on evaluating the economic viability of implementing a system consisting of four solar panels, each with a power output of 570 watts, to power an inverter air conditioner with a capacity of 1 TR. Additionally, it aims to compare this system with the cost of obtaining electricity from various sources, including the electrical system, the private sector generator, and the residential generator.

- Input power (W) =1150, 1TR.
- System components (4 Solar panels longer with a capacity of 570 watts).
- (Inverter capacity with Includes internal charger 3.6 kW).
- (Two batteries Livguard type, capacity 200AH, 12V).
- The total cost of the system 1,800,000 million IQD Include transportation and installation.
- EER = (Cooling load (BTU/h))/ (power input (w)) =10.43.
- The total amount of power consumed is measured in kilowatt-hours (kWh) for both 12-hour a day and 30-days cooling periods within a given month.
- T.E.C = (Q (BTU/h))/EER9 *1/1000 *12*30 = 12000/10.43 *1/1000 *12*30 =414.18 (KWh) where:
- T.E.C: system's total electricity cousmption in kilowatt-hours (KWH).

In order to determine the cost, the unit price for the facility (residatial) is 10 IQD, as indicated by the Ministry of Electricity's prices, as shown in Table 1.

Table 1. Electricity pricing

Consumption Type	Consumption Rates	Unit Price (Iraqi Diner ID)
Residential	1-1500	10
	1501-3000	35
	3001-4000	80
	4001-and above	120
Commercial	1-1000	60
	1001-2000	80
	2001-and above	120
Governmental	No categories	120
Industrial	No categories	60
Agricultural	No categories	60

- Cost for one month =414.18 *10 =4,141.8 IQD.
- During the summer months (6 months) =24,850.8 IQD.
- Electricity is used to operate air conditioner for private sector (take 7A from generator) 70000 IQD.
- 70,000*6 month =420,000 IQD in 6 month (For Local generator).
- The total amount =420,000+24,850.8=444,850.8 IQD. (Per year).
- 1,800,000/444,850.8=4 years.
- So, need 4 years as a payback period.

The low price of residential electricity falls within the first tranche. The lower the exchange rate, the longer the amount will be recovered within a longer period. The air conditioner is included with the first tranche. Its price is 10 dinars. There are many electricity outages in Iraq, which reach about half the time, especially in the summer. In the future, electricity prices may increase and the amount will be recovered faster. If a house uses several air conditioners, the amount of electricity used will increase, and thus the bracket used will change, as you used one air conditioner, and the amount of electricity withdrawn fell within the first bracket, and the price of the bracket was low, so it took four years to recover the amount.

3.2 Sample for calculation

As mentioned before different values of air conditioner capacity has been selected to explore the pv system requirements for wide range of energy consumption. Following is a case study for calculations for this purpose 1TR (12000Btu/h) AC is selected [26].

- Case 1 air conditioners (12000 Btu/h).
- Annual consumption 0.875 kW, type media, 1TR.
- The energy that the device consumes per day = Number × device capacity × working hours.
- The energy that the device consumes per day = 875×1×12 = 10,500 WH.
- Energy required = Total energy consumed per day × 1.3.
- = 10,500×1.3.
- = 13,650 WH = 13.65 KWH.
- Energy of the panels needed = energy to be generated / rate of solar radiation per day = 13.650/5.6 = 2.43 KW.
- No. panel = power of the panels needed / capacity of the panel we want to buy.
- = 2430/570.
- = 4.2≅3 as shown in Figure 3.

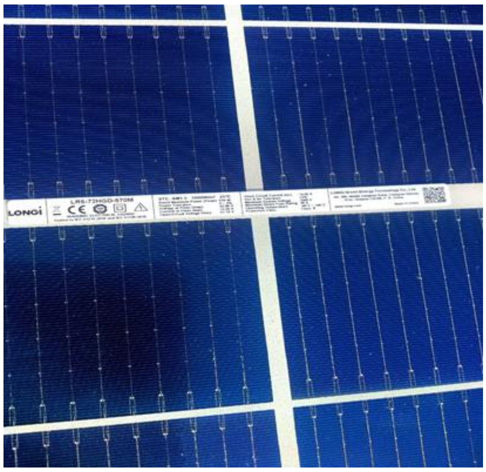

Figure 3. Solar panel selected

- Battery capacity (Amp per hour) = {Power to be generated × Number of cloudy (days during which the panels will be interrupted) × 1.3 (It is necessary to keep 30% of the capacity batteries to keep it) / voltage.
- = (2430×2×1.3) /12 (It is necessary to keep 30% of the capacity batteries to keep it)
- =526.5 AH, choose batteries 200AH, 12V Figure 4.

Figure 4. Batteries selected

➢ Number of batteries = Batteries capacity / Size of battery to be purchased.
➢ =526.5 /200.
➢ =2.6325≅3.
➢ Isc of panel selected = 14.06 A.
➢ The number of panels planned to be installed in the system × Isc (the highest charging ampere for the panel).
➢ 4×14.08=56.24 Amp, 24 v.
➢ So inverter size=875×1.3.
➢ =1137.5 watt.
➢ Is preferable to double the size as a precaution in the future, if we want to expand the system to work for a longer time or add other devices [27].

Iraq suffers from electricity shortages and faces numerous challenges to meet and overcome current and future increases in electricity demands. The scientists agreed that the future of energy efficiency and safety would rely heavily on the implementation of green and renewable energies. The monthly average sun radiation for Thi Qar city [28], as shown in Table 2.

Table 2. Monthly average horizontal solar radiation in (kWh/m²/day)

Jan.	Fab.	Mar.	Apr.	May	Jun.
3.18	4.15	4.82	5.51	6.61	7.60
Jul.	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
7.22	6.84	5.69	4.12	3.03	2.78

The average daily energy received on a horizontal surface is 5.6 kWh/m² annually, and solar radiation can be enhanced on a slanted surface. Thus, Iraq receives a high solar radiation of 2064.32 kWh/m²/year [29], Sunny hours in Nasiriya are (8.5) hours as depicted in Figure 1 [30].

4. RESULTS AND DISCUSSION

Figure 5 represents the variation between the area of the solar panels and the capacity of air conditioner when adopting several operations for the air conditioner, 1 TR, 1.25 TR, 1.5 TR, and 2 TR. From the figure, it can be observed that the area of the solar panels increased with the increase in the capacity of the air conditioner and for several capacity of air conditioner operations and the reason.

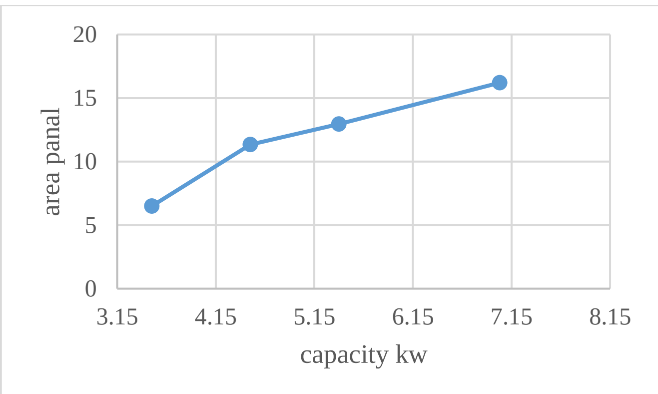

Figure 5. Variation of panel area with AC capacity

When an air conditioner is operated at a higher capacity, the demand for electricity increases, and therefore the system needs more energy to meet this demand. The area of solar panels increases to ensure the provision of sufficient energy to operate devices continuously. The relationship between solar radiation and the area of solar panels is mainly related to the efficiency of converting solar energy into electrical energy, as well as the ability of solar panels to generate energy. The amount of solar radiation depends on the geographical location, time of year, weather conditions, and solar inclination angle. However, the area of solar panels determines the amount of solar radiation that can be received. Expressing it as electrical energy, the amount of energy produced increases by increasing the area of the solar panels, but this increase is not always linear due to the effects of efficiency and radiation distribution. By increasing the area of the solar panels, a larger amount of solar radiation can be received, which leads to an increase in the energy produced. In ideal conditions, the relationship is linear, meaning that doubling the area Solar panels lead to a doubling of the energy produced, but this relationship may be affected by factors such as efficiency and environmental conditions. In short, the relationship between solar radiation and the area of solar panels depends on efficiency and operating conditions, and the relationship is usually linear in ideal conditions.

Figure 6 represents the variation of the number of panels and the radiation when adopting of air conditioners with different loads, 1 TR, 1.25 TR, 1.5 TR, and 2 TR air conditioner at different levels of radiation.

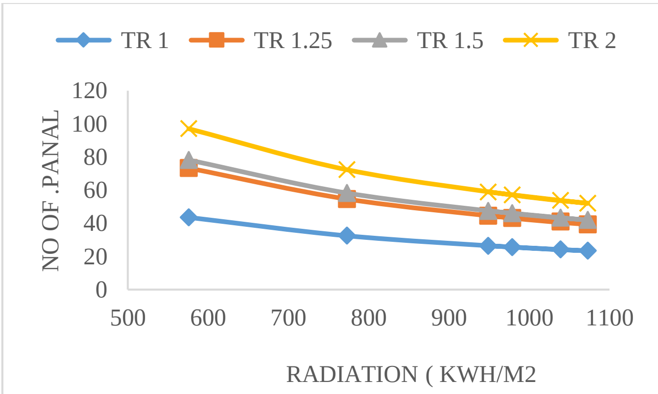

Figure 6. Variation of No. of panel and radiation

From this figure, it can be observed that the number of panels decreased with increasing solar radiation, and for all air conditioner capacities. The reason is through theoretical calculations. The law is that due to the increase in solar radiation, the greater the radiation, the less the solar panels. According to the above equation, the radiation It is inversely proportional, it is in the denominator, and therefore as the radiation increases, the solar panels say since increasing the solar radiation leads to increase the productivity of solar panels. The absence of solar radiation or the absence of solar panels, the energy is zero. We notice from the curve that the relationship is almost linear between solar radiation and the generated energy. Increasing the solar radiation leads to an increase in the generated energy in a proportional manner. The more the number of solar panels increases, the more the generated energy increases. Increasing the number of solar panels is beneficial. Only if there is sufficient solar radiation and without sufficient radiation will the additional panels not generate significant additional energy.

The graph gives us a clear understanding of how the number of solar panels and solar radiation affect the energy generated.

This information can be very useful in designing solar systems effectively and intelligently.

Figure 7 shows the variation of the numbers of solar panels with air conditioner capacity from the figure, it can be seen that the number of solar panels increases with the increase in the capacity of the air conditioner due to needing from more electrify with higher capacity When designing a solar energy system to generate a limited amount of electricity, the total required capacity is related to the number of solar panels used. This curve will be linear in general because the total capacity of the solar panel system depends directly on the number of panels and its individual capacity, as the total capacity increases with the increase in the number of solar panels. This curve can be used. To determine the number of solar panels required for a specific system based on the required capacity.

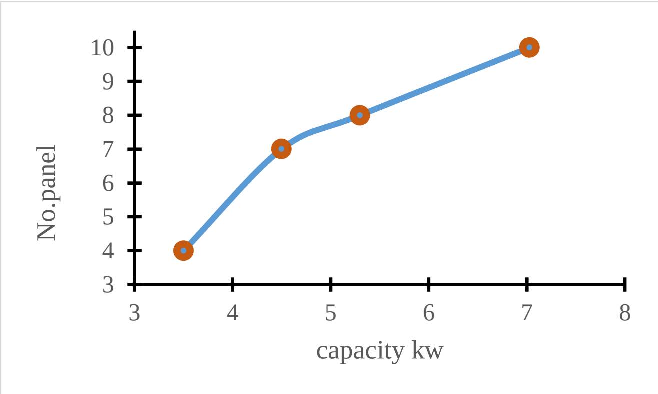

Figure 7. Variation of No. of panel and AC capacity

Figure 8 represents the variation of the number of batteries and with total consumption of the air conditioner for on different loads. Through the figure, it can be seen that the number of batteries increases with an increase in the total consumption for all different loads of the air conditioner. When the overall consumption of the air conditioner increases, the air conditioner needs more energy to operate properly and efficiently, since the batteries provide energy to operate the air conditioner, increased consumption mean the batteries will discharge more quickly. To compensate for this, the number of batteries must be increased to ensure continued power supply.

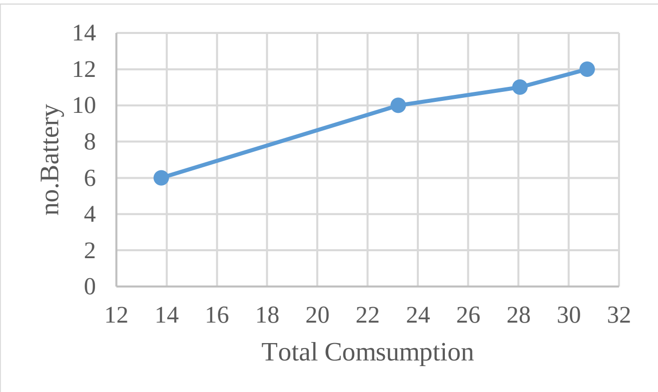

Figure 8. Variation of No. of batteries and total consumption (kW)

Figure 9 illustrates the relationship between the area of the panels and the radiation intensity for various air conditioner loads. It is evident that the size of the panels directly correlates with the level of solar radiation intensity for various air conditioner loads. The rise in load is attributed to the efficient utilization of solar energy for air conditioning operation and heating requirements, hence diminishing the necessity for a bigger solar panel area. The relationship between solar radiation and the area of solar panels is mainly related to the efficiency of converting solar energy into electrical energy, as well as the ability of solar panels to generate energy. The amount of solar radiation depends on the geographical location, time of year, weather conditions, and solar inclination angle. However, the area of solar panels determines the amount of solar radiation that can be received. Expressing it as electrical energy, the amount of energy produced increases by increasing the area of the solar panels, but this increase is not always linear due to the effects of efficiency and radiation distribution. By increasing the area of the solar panels, a larger amount of solar radiation can be received, which leads to an increase in the energy produced. In ideal conditions, the relationship is linear, meaning that doubling the area Solar panels lead to a doubling of the energy produced, but this relationship may be affected by factors such as efficiency and environmental conditions. In short, the relationship between solar radiation and the area of solar panels depends on efficiency and operating conditions, and the relationship is usually linear in ideal conditions.

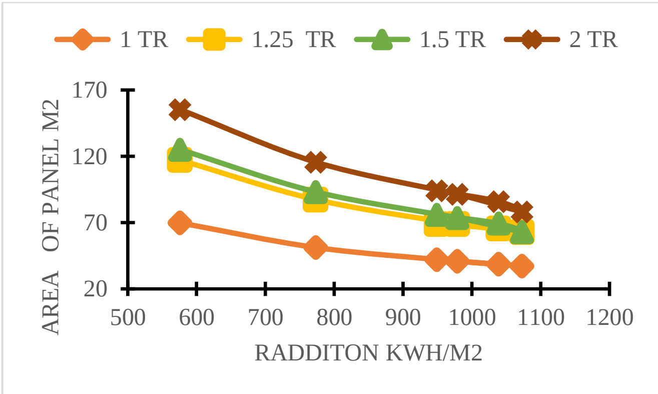

Figure 9. Variation of panels area and radiation

5. CONCLUSIONS

Based on the experimental findings, subsequent observations can be made.

1. The results showed that the number of solar panels increases with the increase in the capacity of the air conditioner ،as more electrical energy is needed to operate the load.
2. The difference between a traditional air conditioner and a solar air conditioner is based on the level of energy preservation, leading to financial savings and ecological sustainability. The economic viability of solar energy consumption has been demonstrated. Ecologically sustainable and continuously replenishing.
3. The solar panel system exhibits the ability to provide consistent and reliable air conditioning throughout the summer, irrespective of the geographical location, be it a hot summer.
4. The environment of Thi-Qar exhibits favorable conditions for the implementation of a photovoltaic solar On-Grid system ،as evidenced by the favorable and encouraging performance analysis outcomes, not with standing the elevated

ambient temperature during the summer season.

5. the payback period is a relatively short duration of 4 years, suggesting significant energy conservation and notable decreases in emissions.

6. Can be confirmed in clean energy electricity generation through On-Grid PV solar systems. The implementation of solar energy investments in the nation has the potential to mitigate the disparity between power generation and demand, while also mitigating the environmental pollution associated with conventional energy production processes in power plants and factories.

7. The difference between a traditional air conditioner and a solar air conditioner is based on the level of energy preservation, leading to financial savings and ecological sustainability. The economic viability of solar energy consumption has been demonstrated. Ecologically sustainable and continuously replenishing.

8. an extensive bottom-up approach is conducted in seek of cost estimation by determining the costs of all the components that the solar project breaks into. Afterwards, a financial cash flow chart is drawn and then to decide whether this project is justified or not upon a numeric evidence. Apparently, by having a quick look at the economic parameters of the solar project one could conclude that it is economically justified.

9. The air conditioner system design for PV panels demonstrated the system's strong research interest and implementation worthiness.

10. The aim of the study was to estimate the efficiency of the air conditioning system, which It runs on solar energy.

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