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Technical Evaluation and Optimization of the Arrangement of the Small off Grid Photo-voltaic System in a Case Study in Iraq

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Abstract: - Due to the growing global demand for electricity, the need for electricity production has increased. However, rising natural gas prices and regulatory emphasis on limiting greenhouse gas emissions have raised the cost of electricity generation using fossil fuels. For this reason, the shift toward using alternative energy sources for electricity generation, including solar electricity via photovoltaic systems, has gained traction. Photovoltaic systems are widely used due to their many advantages: a long lifespan of about 20 years, the ability to install and operate in mountainous geographical conditions, suitability for mobile systems, easy maintenance, independence from the grid in remote locations, and connectivity to the grid, all of which provide a promising future for these systems. In this research, two case studies in specific locations in Iraq (Karbala Province and Erbil Province) have been selected for photovoltaic panel modeling based on latitude and longitude. The simulation of the photovoltaic panel was conducted using PV-Syst software for these areas. The results show that the optimal angle for the photovoltaic panel to improve the system's efficiency in Karbala Province is approximately 31 degrees, which enhances the system's efficiency and performance, resulting in a production capacity of 1815 kWh/year. The optimal angle for Erbil Province was determined to be 33 degrees, generating 1743 kWh/year.

Keywords: Photovoltaic system, Solar energy, optimization, case study in Iraq, optimal angle, PV-Syst software.

INTRODUCTION

As the world's energy demand increases, the need for energy (electricity) is also increasing, the cost of extracting and transporting fossil fuels and implementing recipes based on removing harmful ozone substances and reducing air pollution, and the overall price has increased the production of electricity from nonrenewable fuels.

However, the advantages of using solar energy in our current era have expanded to the use of photovoltaic panels.

The long life of this system (about 20 years), the ability to provide variable input and work, the ability to install in rugged and mountainous terrain, as well as installation in portable (mobile) systems, simple support, no reliance on the grid in remote areas, and the possibility of using it

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appropriately with the national electricity production and distribution network are some of the advantages that paint a bright future for the use of photovoltaic frameworks.

Advances in technology and the development of innovations used in the creation of photovoltaic cells have increased the ability to use these methods.

The cost of designing and building photovoltaic systems has been reduced by approximately 20% compared to the past 20 years, and the number of experts who specialize in installing photovoltaic modules has doubled [1].

Over the past long time, due to the advance in sun-based board advancements, the plausibility of utilizing these frameworks in different businesses has been given, e.g., the electrical energy produced by photovoltaic technology has been used in space rockets since the beginning. Today, due to its commercialization and recent progress, it is used to supply electricity to urban and agricultural areas.

Given that there are different types of photovoltaic system, they all consist of three primary parts:

• Solar energy conversion unit;

• Converter that converts regular energy to alternative current (that can be used for household consumption);

• Battery that plays a role in energy storage

Other sub-sections of this system include cables, flow control systems, support systems, etc., which must be determined to use this system better.

In addition, to improve the performance of the electrical grid and prevent electrical stress in power plants during the day, the use of photovoltaic systems compatible with the public electricity grid in an integrated and decentralized manner is one of the proposed methods.

Today, photovoltaic systems are being built in different countries in units of 1 to 5 kW on the roofs of residential buildings and on a large scale in solar power plants [2].

Photovoltaic power generation, as a key to the increasing demand for electricity, allowing the mitigation of environmental and social issues linked to fossil fuels and nuclear fuels [3-4]

According to the facts of environmental pollution and global warming caused by numerous fossil fuel-powered electricity generation systems, this era is the generation of photovoltaic energy, which is one of the largest and prominent renewable energy generation methods in the world. Due to the immediate growth of research and development in the solar energy industry, the cost per kilowatt has dropped by approximately 60% since 2019, and it is expected to decrease further in the future [5].

Photovoltaic systems are characterised by inferior investment costs ease of installation, low maintenance requirements, and quick assembly [6].

In addition, through photovoltaic systems, we can ensure stable energy supply and reduce dependence on central electricity grids, The value of the property. However, the rate increases with the installation of photovoltaic systems and can help improve the efficiency and attractiveness of the building.

However, these systems also help conserve water resources because they require less water to produce energy, which leads to the conservation of water resources and reduces their consumption.

In general, solar photovoltaic energy contributes to a sustainable future in energy [7].

2. THE OVERVIEW IN THE ENERGY SECTOR AND PROSPECTS FOR SOLAR PV IN IRAQ

The electricity sector in Iraq is inefficient due to the strike that occurred as a result of the destruction of the country in 1991 and the increasing demand for energy by its growing population. At present, electricity generation in Iraq is not sufficient to meet the energy needs of the industrial and domestic sectors as a result of the conflicts that it has witnessed [8].

The Iraqi energy sector is currently degraded by a pronounced imbalance between electricity production and consumption, with visit systematic power lacks and an overreliance on imported energy, the country's energy infrastructure is especially dependent on fossil fuels, contributing to high degradation in the energy sector in Iraq. Be that as it may, Iraq's geographic and climatic conditions propose a solid potential for the selection of solar-based [9-10-11].

Moreover, solar energy may meet the broad energy needs of citizens, as the potential of solar energy in Iraq is extremely high, free, and unlimited for all [12].
Energy resources in Iraq are a very vital issue due to its social and economic importance, Iraq is one of the largest oil exporting countries in the Middle East, whose economy is significantly dependent on oil and accounts for approximately 91% of its government's exports, and Iraq's oil resources are very rich in terms of number and potential, most of which are located in the south and north of the country. In terms of natural gas resources, Iraq has many resources and has the largest natural gas reserves among neighboring countries. However, these resources are not exploited sufficiently because a large amount of natural gas is wasted.

In the future, Iraq has vast potential in the field of solar energy, will have many possibilities to implement solar energy systems in this country, and among these possibilities are various factors such as geographical location and the number of sunny days per year.

Iraq is found between scopes 29.50 and 37.220 north, and between longitudes 38.450 east and 48.450. The Iraqi zone is 435,052 km2. Northern Iraq comprises mountains of the sort where sunny days are not as they are in other parts of the nation, particularly in winter. The center portion of Iraq is mainly a plane ground between two fundamental streams, the Tigers and the Euphrates, where daylight is more than within the north, The southern part of the country is an area of

outstanding pure atmosphere except when there is a dusty storm from the desert; otherwise, this area can be considered as one of the highest solar radiation regions[13]

Iraq's geographical location is particularly suitable due to the sun is available consistently throughout the year, making solar energy production remarkably efficient, These factors assist reduce reliance on fossil fuel sources, The use of clean energy creates a significant improvement in the environment, reduces the amount of greenhouse gas emissions, and leads to a significant improvement in the health and quality of life of citizens. Producing large amounts of electricity through solar energy can be effective for remote and rural areas that do not need infrastructure to produce electricity from fossil sources.

However, the energy obtained from the sun is easier than other types of energy in the central countries, especially in Iraq. Therefore, the significant measures now show a great opportunity to use advances in solar energy [14-15].

3. REVIEWS OF THE LITERATURE

3.1 Background of review of the literature on renewable energy.

The study presents the potential of renewable energy in Iraq and solar energy in a special way, as it shows a future outlook on renewable energy in Iraq and how the potential of solar energy can contribute to the improvement of energy. It explains the capabilities that characterised Iraq, as it can play a clear role in enhancing energy despite Although solar energy is not widely used in Iraq, solar energy sources in Iraq are considered widespread despite the limited solar energy activities in the country. Furthermore, the attempts of the study show the Iraqi government to turn to solar energy sources in various activities and types [16].

The study clarifies the prospects for renewable energy in Iraq, as it explains the aspects of suffering in the electrical energy sector in Iraq that the country, as the study showed that solar energy sources are among the sources in which the density of solar energy in Iraq is among the highest in the world. In general, renewable energy sources are not clearly exploited in the country. When renewable energy sources in Iraq are properly and extensively, they can reduce the electricity shortage that occurs in Iraq [17].

The study shows the prospects that renewable energy has gained in importance due to the positive aspects it possesses. Subsequently, the study shows that Iraq is qualified in the field of renewable energy despite not using renewable energy sources, as solar energy is the most suitable alternative in Iraq from renewable energy sources that can replace fossil energy sources. On the one hand, it is a suitable and, appropriate source, and on the other hand, it is less expensive and safe for the environment. Moreover, solar energy may be one of the alternative sources in Iraq [18].

The study shows a review of the energy situation in Iraq and the role that most countries the Arabian Peninsula adopt on solar energy sources and the lack of orientation toward it due to the

fact that the cost of oil is inexpensive and can be easily accessed. Therefore, which prompted most of these countries not to realize the importance of renewable energy and what its role is. Which it plays in improving the environment, as it explained that countries in this region, as well as Iraq, do not realize the importance of renewable energy compared to its theory of fossil energy sources that cause environmental impacts [19]

The study presents the reasons for the shift to renewable energy sources, including the environmental impact and demand for electrical energy, prompting research and exploration on sources that are environmentally friendly. Furthermore, the study shows that electrical energy is currently a challenge for developing and developed countries in meeting the demand for electrical energy sources, leading to the search for renewable energy sources such as solar energy, which is an abundant source [20].

The study focusses on evaluating the methods used to find alternative sources, as the study presented stand-alone hybrid to improve energy sources. This resource is an important indicator of development. In addition, the study presents the positive and negative aspects of the systems, as the photovoltaic systems are characterised by sustainability and environmental non-influence. During the study, it was integrated with fossil energy resources to improve photovoltaic energy systems in blocking energy demand. Although fossil energy sources cause buried emissions, these sources send a large amount of gases to the atmosphere [21].

The study is analyzed through global assessment aspects that determine the capacity of renewable energy systems with fossil fuels by 2050 and whether renewable energy systems can replace fossil fuel systems. However, the impact of fossil energy sources on the climate is one of the broadest threats to humanity, as through this study shows that renewable energy systems can replace fossil energy systems by 2050. In addition, through renewable energy systems, threats of climate change caused by fossil fuel systems can be eliminated [22].

The study presents the effects of electrical power outages in Iraq and the lack of energy coverage, since this crisis still exists in the country, resulting in the trend towards fossil energy sources, such as diesel generators, which are relied upon, as telecommunications companies such as Zain, Asia Cell, and others in Iraq use these sources to cover their consumption, and the study showed the effects of these sources on humans and the environment, as they are considered toxic sources [23].

3.2 Analysis of aspects of the stand-alone photovoltaic system

The study presents the importance of solar energy by reviewing the technology of tracking the sun, and it analyzed the most exploratory methods followed by the world to identify more effective and feasible ways to harness the tracking of photovoltaic energy systems, as it is an important source. It also explained that solar energy is characterised by abundance and is a free source, as it is considered to come from environmentally friendly renewable sources. On the other hand,

through the dual-axis tracking systems that the study focused on this type has proven to be superior in terms of efficiency and benefit over its counterparts of the single-axial type and fixed type [24].

The study presents the Dependability Analysis of photovoltaic energy systems by analyzing the long-term performance of Independent Photovoltaic Energy Systems. It discusses the quality of the photovoltaic system and the advanced energy service. It also showed that independent photovoltaic systems should provide good quality electricity services that should be taken into consideration as alternative energy sources rather than sources energy traditional in places that do not have access to electrical power (i.e., in rural areas), where independent photovoltaic systems in rural places must include reliability. However, the application of reliable methods to photovoltaic systems may contribute to improving the performance and quality of independent systems [25].

The study presents the design of a photovoltaic system Al-Hilla Governorate for an average house in Iraq. The study explains the design that relies on solar energy for independent systems for a house in Iraq, while sizing the system through the use of photovoltaic cells to exploit solar energy in many applications. Thus, it clarifies the focus on exploitation applications. Energy for domestic use, as the study shows the important and clear uses of solar energy that can be relied upon in Iraq, as the country enjoys suitable climatic conditions, where it can be relied upon to cover delays in extension of electrical power and in projects in remote areas, as these systems are considered much necessary in Iraq [26].

This study presents a unique approach to the aspects of covering rural areas with electrical energy through off-grid photovoltaic energy systems. This type of photovoltaic system provides independent electrical energy to families in the Diyala Governorate in Iraq; the study demonstrates the effectiveness of these systems compared to fossil fuel; these systems encourage that they can be used in areas where it is difficult to connect electricity.

However, it appears that the use of off-grid photovoltaic systems is suitable for long-term use in Iraq [27].

The study shows the estimation of the load for solar photovoltaic systems of the type off-grid, which are considered a reliable source of renewable energy for the generation of electricity. On the other hand, these systems can be used in many commercial, agricultural, and other applications, as these systems practically do not require maintenance [28].

The study provides a review of the capabilities of Iraq, which has great potential for solar energy, through this potential, it is possible to reduce the dependence on the electricity grid in the country. Furthermore, solar energy technology in Iraq is an appropriate and applicable option according to all standards. Furthermore, the study showed that the most dangerous obstacle facing photovoltaic energy systems is dust that is suspended in the air for long periods [29].

The study aims to improve the photovoltaic system to adjust the seasonal trend in Karbala, Iraq, by identifying cost-effective methods (to enhance the incident irradiation at the complex level)

Two different directions of photovoltaic energy in Iraq. Furthermore, the study showed that a photovoltaic system with a capacity of 690 kilowatts was used, as this system was designed for office purposes, that is, in office applications in the Karbala Governorate in Iraq, taking into account three important factors, including the seasonal inclination angle with albedo of 0.25, and following the horizontal axis system of 0.25, the inclination angle Seasonality, material With whiteness, as the results showed, the cost of the photovoltaic system decreased with changes occurring in improving the efficiency of the system with less expensive materials [30].

The study shows the importance of photovoltaic systems, as they are technically and economically feasible systems, as through the design and sizing of the standalone system, in this study the feasibility of generating the photovoltaic system with diesel systems was analyzed. Which was applied in the city of Sebha as a case study in Libya, where the demand for electrical energy was 61,894-kilowatt hours / day, the results showed that the capacity of photovoltaic cell systems reached 15.6 kilowatts, requiring 86 units and 16 batteries (12 volts, 375 amps/hour). 18.9 kVA inverter, 48 VA inverter, 60 amp and 24 voltage regulators to supply the electrical load and copper wires with a cross-sectional area of 1.47 mm, 39.33 mm, 4 mm for installation. The results show that their cost is relatively high, but if their lifetime is considered, these standalone photovoltaic systems will be satisfactory and appropriate and can be competitive with the diesel facilities that operate [31].

The study provides a mechanism for improving Resiliency PV systems through the maximum power point tracking algorithm (MPPT) via the constant or variable solar radiation in improving the performance of the systems. the other hand, the photoelectric system also shows the role of battery systems in improving the performance of photovoltaic systems, as the results showed that batteries have the ability to improve the performance of photovoltaic systems by controlling the loading operations, the unloading During sudden pregnancy management, the performance of the photovoltaic system can be enhanced in this case [32].

In this work, an evaluation of the performance of standalone photovoltaic systems is presented for rural communities. The study shows that photovoltaic energy systems are considered one of the best energy sources in remote areas for generating energy through independent photovoltaic energy systems. Moreover, this type of system is considered an alternative source of national electricity in representative areas [33].

In this work, he highlights the aspects of energy poverty in millions of developing countries. However, the performance evaluation of the solar photovoltaic system showed a discussion of the stand-alone system, with a battery system as it could be a possible option in rural areas in electricity coverage. It can contribute to alleviating energy poverty in developing countries around the world [34].

In this work, the study explains the design and improvement of a standalone photovoltaic system for rural communities, since numerous areas in Egypt live without electricity due to their locations being far from the electricity network. The study shows the use of standalone

photovoltaic systems for a family with an area of 50 meters in a rural area located in Shalateen (Egypt). It showed that these systems have been proven effective in use in rural areas, which will encourage their use [35].

The study presents an approach to stand-alone photovoltaic energy systems, as it shows that independent photovoltaic energy systems are convenient systems for people far from the electrical grid. Furthermore, for those who want energy sources that do not depend on the electrical grid to cover their electrical energy consumption activities system and, on the other hand, this methodology provides the necessary technical guidance to choose the appropriate location for photovoltaic systems with the resources available for the site, along with clarifying instructions on the components of standalone photovoltaic systems [36].

The study demonstrates the capabilities that characterise Iraq, as it is characterized by wide levels of solar radiation, its enormous geographical location, and the diversity of climatic conditions in the country. The research dealt with selecting ten cities in Iraq to establish solar energy plants to evaluate the quantitative effects of environmental variables in Iraq on saturation losses and reflector efficiency in many different regions of the country. The results showed that the conversion ratio from DC to AC decreases from 1.21 to 1.06, as a result of which the saturation losses of the inverter in off-grid photovoltaic energy systems decrease [37].

In this work, it explains how the inverter affects the reliability of the photovoltaic system. The study shows the reasons for the failure of the inverter, which affects the production of photovoltaic energy during its useful life. Prediction periods through downtime related to failure must be included in the life cycle cost of photovoltaic systems, the study explained the reasons for failure that occur, In the inverter It included the reliability characteristics of the inverter, inverter repair time, and inverter configuration [38].

3.3. The effect of dust on the photovoltaic system.

One of the most important components in photovoltaic power plants in a hot and dry climate is the effect of dust on zinc power plant performance. For this purpose, the following studies have been conducted in this case.

The effect of dust on high-capacity photovoltaic power plants related to network in California and the southwestern region of the United States of America, given that this effect is local It is important that there is no precipitation in the summer months as in California and the southwestern region of the United States This research has been done in this article to describe the effects of dust on energy production for network-connected sites in the United States and present a model for predicting dust losses [39].

An experimental research on the effect of dust concentration resulting from factors environment on the performance of photovoltaic modules, In this research, reducing the amount of dust available in the air on the photovoltaic modules in the open space may transfer the solar cell coating and cause a significant decrease in the solar conversion efficiency of photovoltaic modules. This

experimental work was done to study the accumulation of dust on different types of solar photovoltaic modules and analyses the related efficiency done, The experiment was designed and carried out in the laboratory with a sunlight simulator and a test chamber obtained from the experimental results that with increasing the density of dust deposition from 0 to 22 grams per square meter, The PV output efficiency will decrease from 0 to 26%. Consequently, the density of dust deposition is fixed, and the decrease in output efficiency has been much more severe in the case of low and high iodine radiation, the find, another is that the decrease in production due to dust is more impacted by the size of the dust particle [40].

A study on the effect of dust, humidity, and wind speed on the efficiency of photovoltaic cells. The result of their research was that the deposition of dust and sediment on the surface of photovoltaic cells can reduce efficiency. Also, humidity almost always causes a decrease in the efficiency of the solar cell by increasing the wind speed, more heat can be extracted from the surface of the photovoltaic cell deleted, and In the same way, higher air speed reduces the relative humidity of the atmosphere in the surrounding environment. Which in turn leads to better performance of the panels. However, the wind disperses the dust in the environment. This leads to shading on the panels and causes poor performance of photovoltaic cells. Therefore, all the factors mentioned must be considered simultaneously to determine the performance of photovoltaic cells [41].

The losses caused by dust in photovoltaic power plants They measured the effect of dust and pollution on photovoltaic panels is generally hard shading. It is said that it is one of the most important factors in reducing the power production of the photovoltaic power plant. The purpose of this research is that It was how to control the production of the power plant by monitoring the blackout data. They Simulate high levels and rates alongside the performance of photovoltaic power plants in the desert southwest of the United States. Arabian Island and Western Australia studied. Determining the amount of dust loss during analysis the performance of a photovoltaic power plant is of great importance, especially in areas with high dust rates. Accurate measurements of this process are therefore important for both performance prediction and monitoring. They recommended that dust monitoring be used as a standard tool in photovoltaic power plants to be. When used in a preconstruction manner, dust measurement systems can help to estimate the duration of cleaning periods and as a result the cost of cleaning that is required to maintain the us surface a good annual will be needed in dusty places. For the five photovoltaic power plants that here Provided, the depreciation rate of 5/. % to 5% per month will vary. Data collected at five sites, it allows the estimation of the rain threshold required for cleaning, which together with the regional precipitation rate, is a parameter. It is important to predict the future performance of the power plant [42].

3.4. The effect of temperature on the photovoltaic system.

Considering that the average temperature is high in a hot and dry climate, the effects of this temperature on the performance of the modules photovoltaic is important. Past studies in this case are as follows.

The effects of temperature on the efficiency of photovoltaic cells, which are They investigated the nonuniformity of cooling and focused on the arrangement of cooling tubes It was to increase the performance of photovoltaic modules and they concluded that the best design is the design that It that keeps the operating temperature of photovoltaic cells as minimal and uniform as possible, resulting in maximum efficiency The energy of photovoltaic cells becomes [43].

effect of temperature on polycrystalline photovoltaic cells was modelled and they simulated the purpose of this article is to present a simulation model with MATLAB and Simulink software for the module Photovoltaics was based on the one-diode model of a photovoltaic cell made of polycrystalline silicon. This model showed the effect of ambient temperature and panel heating due to infrared radiation of the sun [44].

3.5 Review of the literature on the simulation of photovoltaic panels

Designed a research on the potential of exploiting solar radiation. They did it in Iran. In this research, the optimal azimuth angle is 0 degrees and is facing south. However, hot and dry areas, especially the southern part of the country due to the higher capacity factor, have been introduced compared to northern regions with high potential [45].

Modelling the radiation and temperature response of photovoltaic modules in the software. We have done PV-Syst. In this research, the single diode model is used in the software [46].

The performance of photovoltaic panels installed in They investigated the roof in the hot and dry climate of Iran. In this study, 14 5 kW power plants were installed as studied in Kashan, but according to acceptable results about the technical performance of these power plants, in terms of economic indicators and according to the guaranteed purchase rate of that time in Iran, these power plants were economically According to the return period, they were not justified[47].

Research on LCOE energy balance cost for the route They advanced solar energy. This research was conducted according to the conditions in the United States of America. In this study, they have come to the conclusion that the newer technology is used, according to the following. The higher the purchase price, the lower the cost of the energy balance. Summary Literature reviews highlight the importance of the feasibility of renewable energy sources in the world and in Iraq. It analyses their importance compared to their fossil fuel counterparts and how renewable energy sources, including photovoltaic energy sources, which are more widespread and reliable in these systems, are environmentally friendly sources, unlike fossil fuel sources. However, studies in the

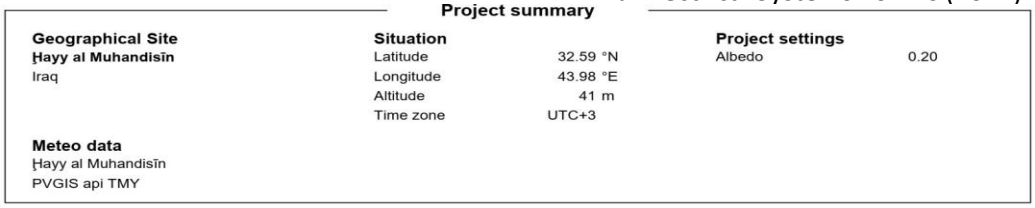

Fig. 1. Project summary for system in Karbala.

literature studies discuss the selection of stand -alone photovoltaic energy systems, which are considered independent photovoltaic energy sources that can be adopted in remote locations where they show the aspects of these systems and the influence of factors that affect the reliability of the performance of the systems, as it discussed the effects of dust and temperatures and their impact on the performance of the independent photovoltaic system [48].

4. Methodology and simulation

We are developing a proposed system seeking from the type grid connecting the electrical grid to improve energy distribution in Karbala and Erbil, In this proposal, we will ascribe our approach to implementing a photovoltaic system, focusing on identifying the optimal tilt angle for both regions, Our struggles will focus on gaining a good system's production efficiency by determining the most effective tilt angle. The results will be derived from the PVSYST simulation process.

4.1. Modelling a Solar Photovoltaic System in the city of Karbala

In this study, the simulation and modelling of a solar photovoltaic system in the city of Karbala are performed using the PV-Syst software as follows:

- Geographical location in Karbala
- Latitude:
- Longitude:
- Power of the designed solar power plant: 100 kW
- Required area: about 500 square meters
- The angle of the panel with the horizon (tilt angle): 30 degrees
- Selected type of solar panel: Longi-Solar-550 W
- Selected inverter type: Huawei-Technology-55kW

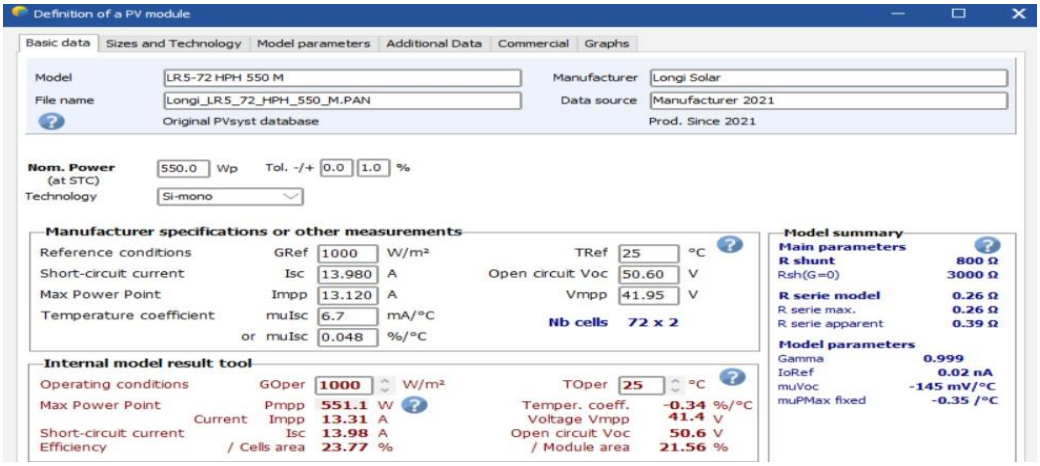

Fig.2. The main characteristics of the selected solar panel

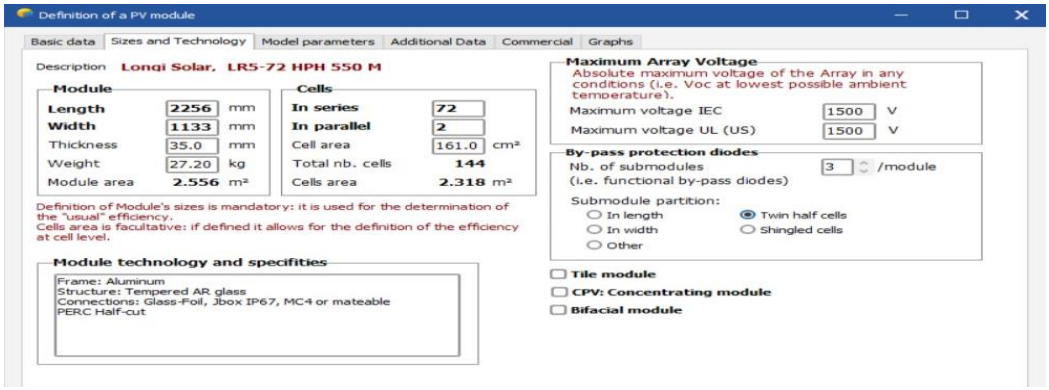

Fig3. Illustrates the dimensions of the selected solar panel.

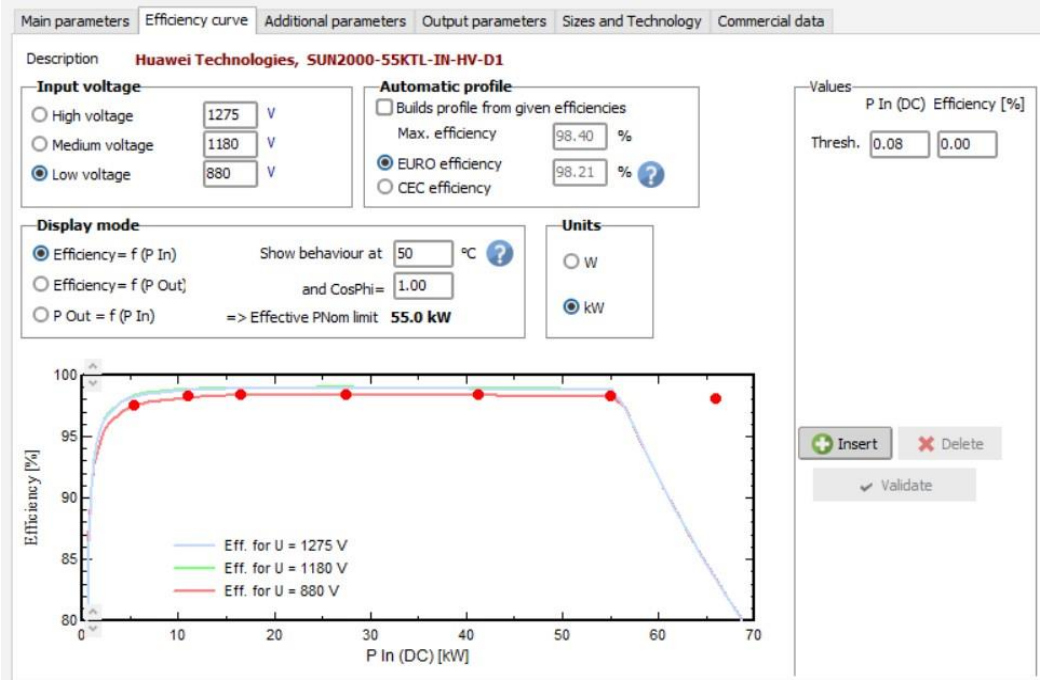

Fig. 4. The functional diagram of the selected solar panel

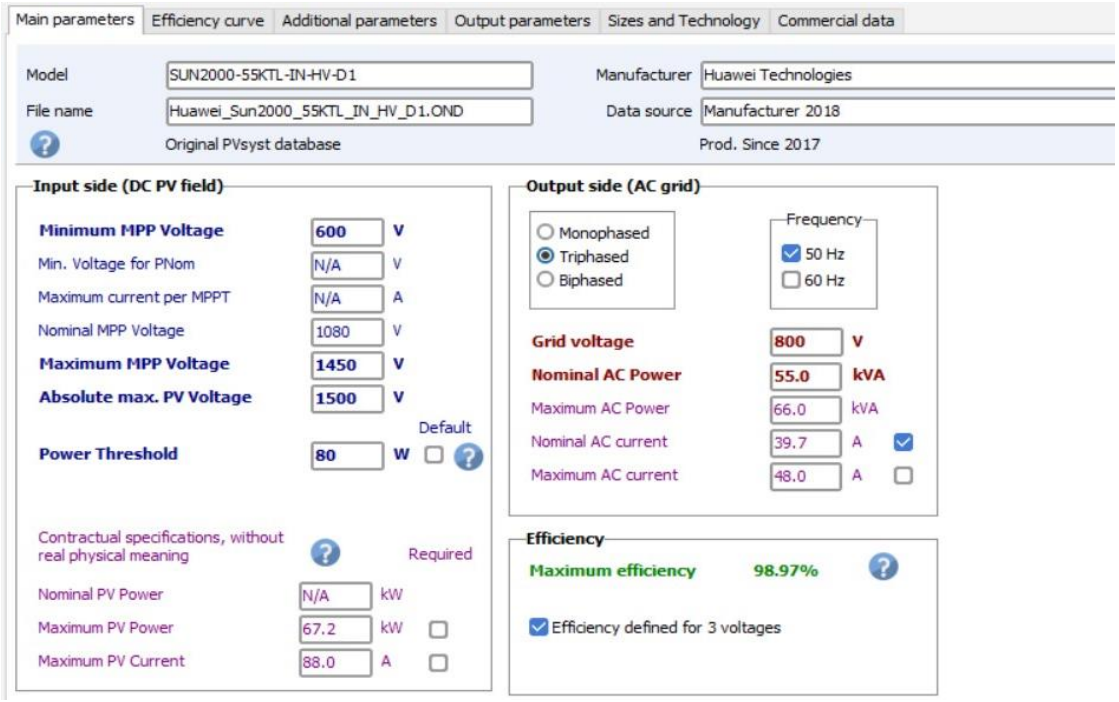

Fig. 5. The main characteristics of the selected DC/AC inverter

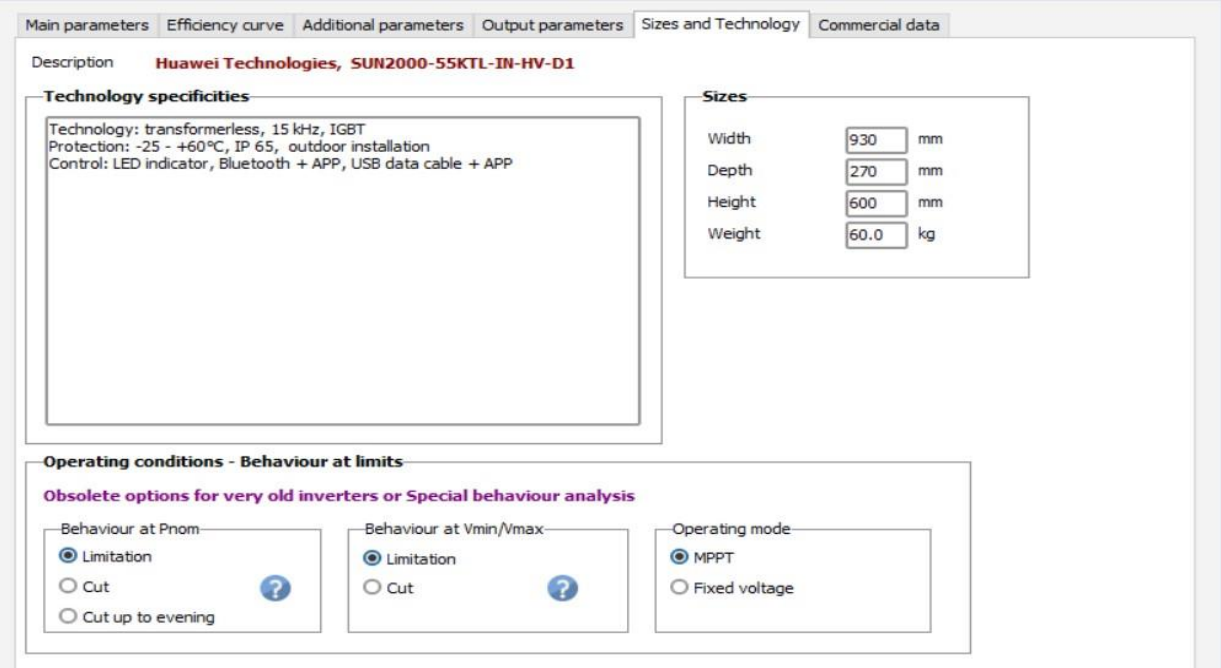

Fig. 6. The performance curve of the selected DC/AC inverter.

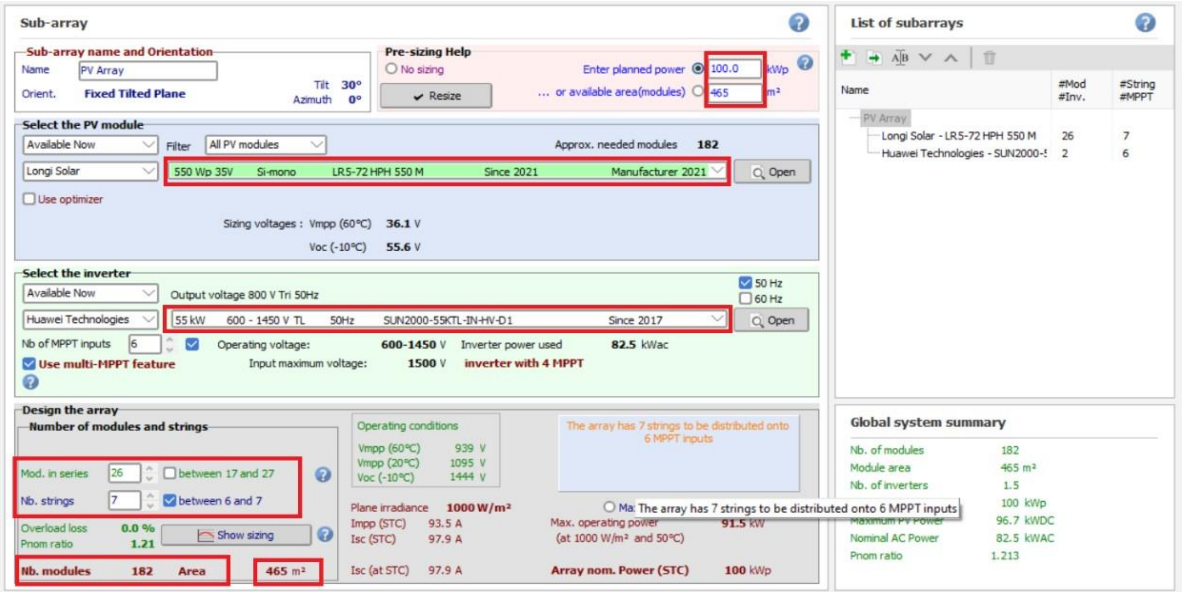

Fig.7. Dimensions of the inverter DC/AC selected

8.LAYOUT OF PV SOLAR SYSTEMS.

The design of this system illustrates the essential design criteria that were used, which were:

The number of rows (I.e. Strings) is 7, the number of panels in each row is 26, and the total number of panels is 182 panels, which is shown in Figure (8).

4.2. Angle optimization for solar panels in the city of Karbala.

The changes in the angle of the panel with the ground surface in the Karbala area according to the production power throughout the year are as follows.

Table 1. Annual production power in terms of panel angle changes in Karbala city

Solar panel angle	50	45	40	35	30	25	20	15	10
Production capacity throughout the year	1747	1778	1800	1812	1814	1808	1792	1767	1732

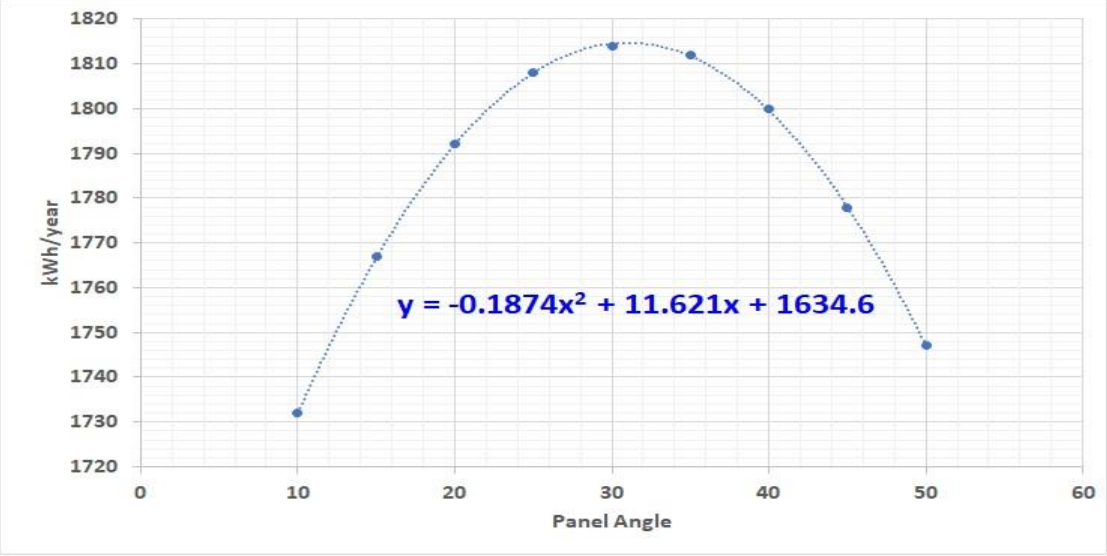

Fig.9. the graph of changes in production power according to the angle of the panel for the city of Karbala

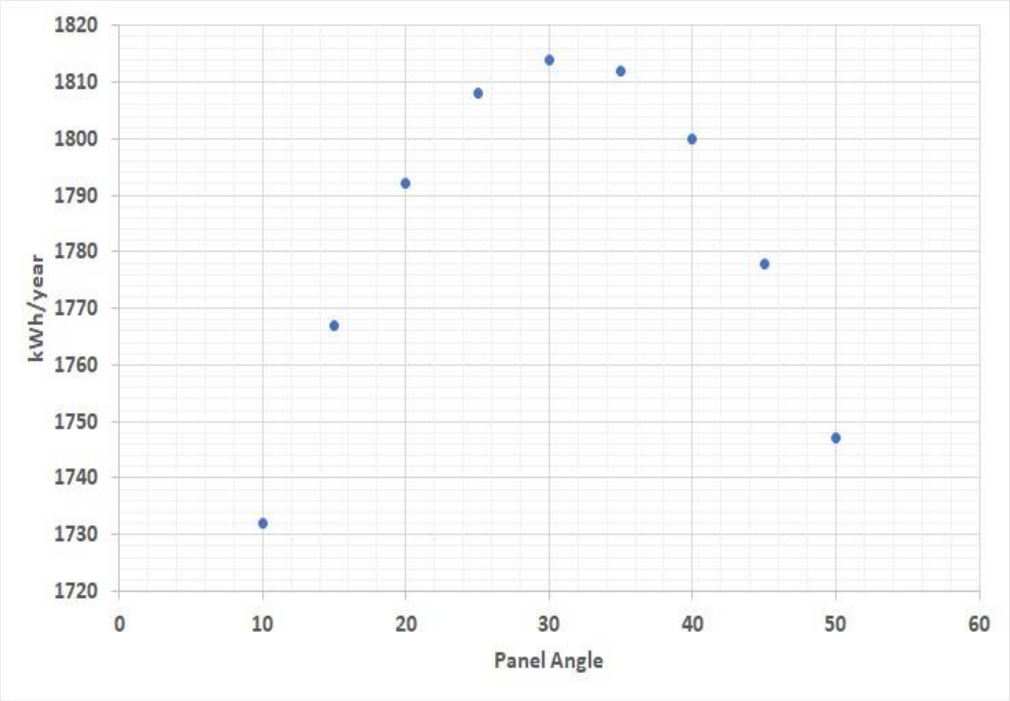

Fig.10.suggested distance curve based on modeled points for Karbala city.

$$Elec\ Power\ (\frac{\text{kWh}}{\text{year}}) = -0.1874\ (Angle)\ 2 + 11.621\ (Angle) + 1634.6$$

$$Optimum: \frac{\text{d Power}}{\text{d Angle}} = 2 \times (-0.1874) \times (Angle\ Panel) + 11.621 = 0$$

System summary

Grid-Connected System		**No 3D scene defined, no shadings**	
PV Field Orientation		**Near Shadings**	**User's needs**
Fixed plane		No Shadings	Unlimited load (grid)
Tilt/Azimuth	31 / 0 °		
System information			
PV Array		**Inverters**	
Nb. of modules	182 units	Nb. of units	1.5 units
Pnom total	100 kWp	Pnom total	82.5 kWac
		Pnom ratio	1.213

Fig.11. Simulation with a 31-degree angle for solar panels

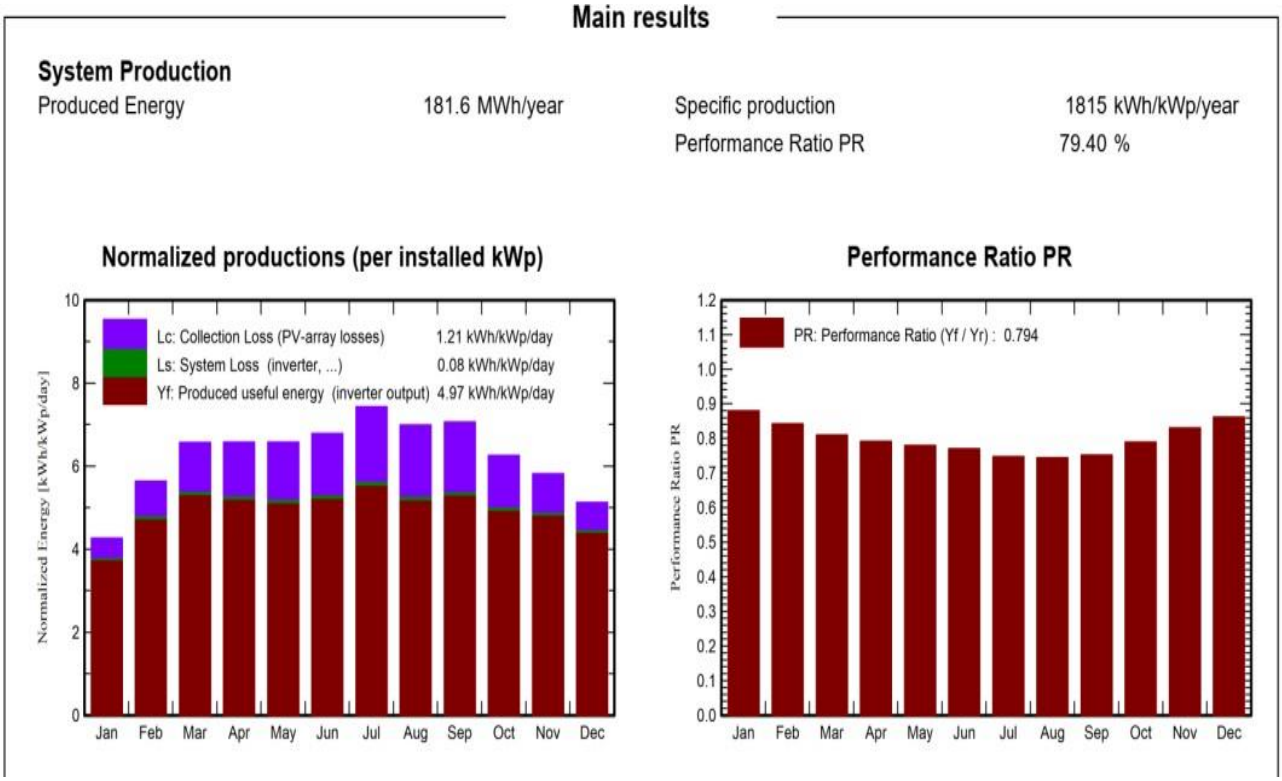

Fig.12. the main results of modeling in the optimal angle in Karbala city

4.3 Modeling of a solar photovoltaic system in the city of Erbil

The system proposed depends on the geographical location in Erbil Governorate, northern Iraq, where the design was made according to the standards of the PVsyst software, where the rate of designing PV system solar power: is 100 kW, the required area for it is about 500 square meters, in orientation tilt/Azimuth).additionally, encompassed Selected solar panel type: Longi-Solar-550 W, Selected inverter type: Huawei-Technology-55kW.

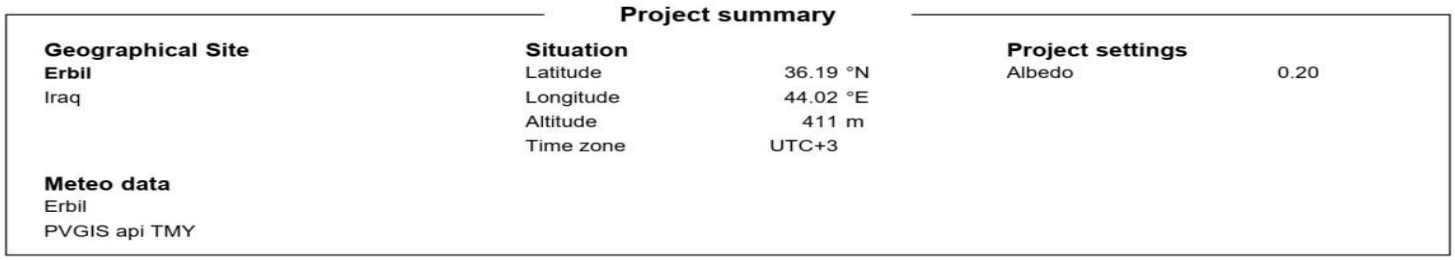

Fig.13.The summary of system in Erbil

4.1 Optimizing the solar panel angle in Erbil city

The sustainable path in Erbil Governorate is a path with broad prospects, as the proposed system reveals how optimizing the efficiency of panels can change the energy paths in Iraq, as in this we have explained a pathway that can improve energy efficiency by finding the manner of selecting a tilt angle that can deliver the loftiest energy production rates by PV solar.

Table 2. Annual production capacity in terms of changes in panel angle in the city of Erbil, Iraq

Solar panel angle	50	45	40	35	30	25	20	15	10
Production capacity throughout the year	1680	1709	1729	1740	1743	1735	1720	1695	1661

The table shows how the tilt angle affects the improvement of energy rates in the photovoltaic system, The more reasonable the tilt angle is the enormous the production capacity throughout the year the tilt angle will be, and the appropriate energy rates will provide in the photovoltaic stations, which will lead to improving energy production in Erbil Governorate in the future, as the tilt angle at 30 dramatizations the highest rates of energy for the system compared to other angles of tilts.

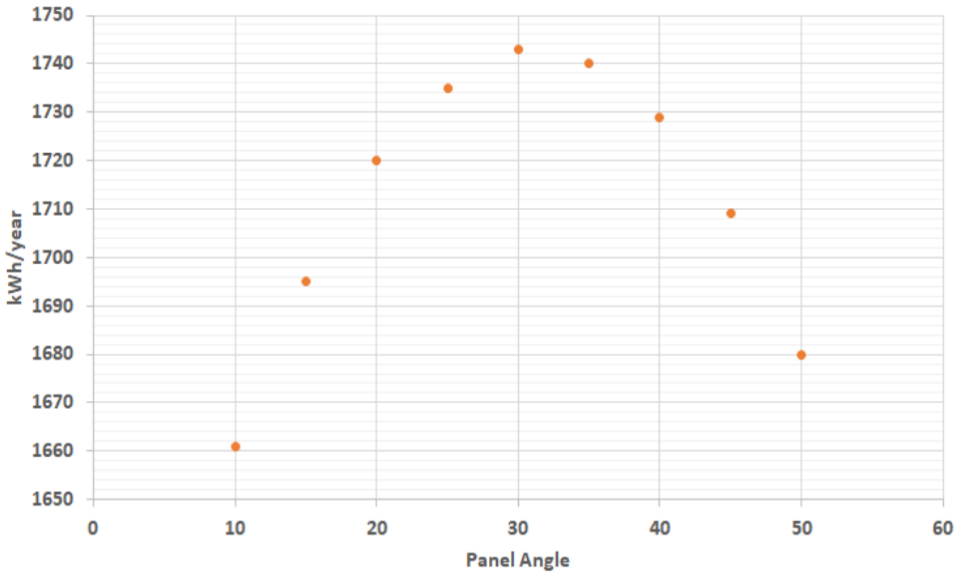

Fig.14. the diagram of changes in production power according to the angle of the panel for the city of Erbil.

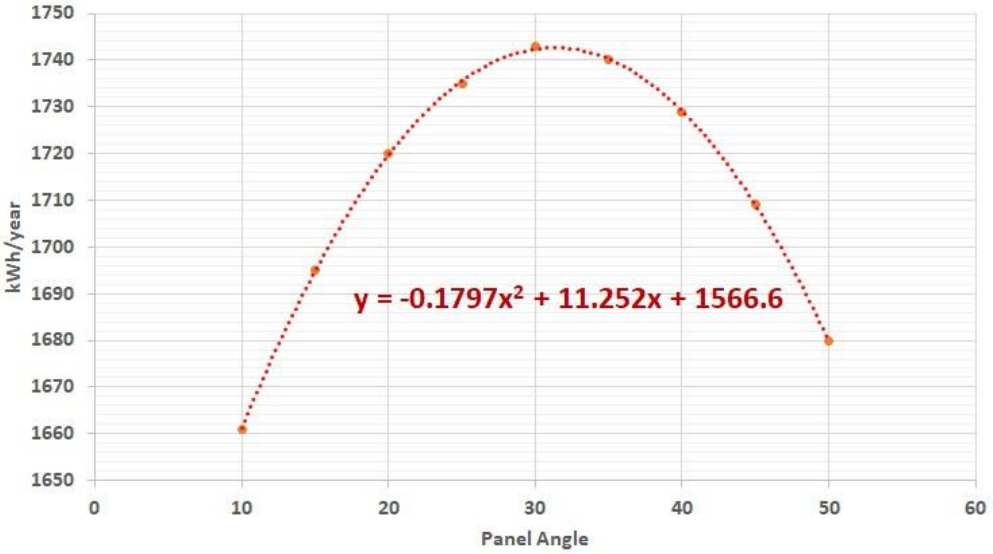

Fig.15. indicates for distance curve based on modeled points for Erbil city.

$$Elec\ Power\ (\frac{\text{kWh}}{\text{year}}) = -0.1797\ (Angle)\ 2 + 11.252\ (Angle) + 1566.6$$

$$Optimum: \frac{\text{d Power}}{\text{d Angle}} = 2 \times (-0.1797) \times (Angle\ Panel) + 11.252 = 0$$

$$\text{The Best Angle of the Panel} \frac{11.252}{2 \times 0.1797} = 33$$

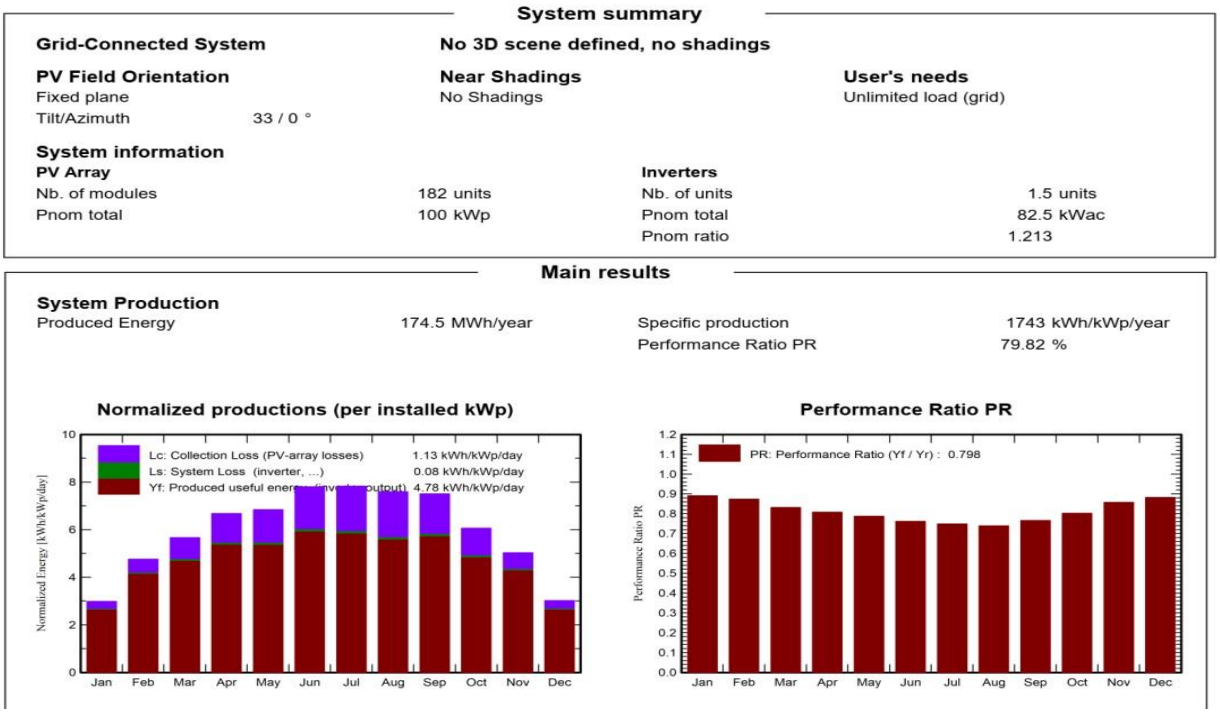

Fig.16. the main results of modeling in the optimal angle in Erbil city

CONCLUSION

One of the best options for electrical energy in Iraq is solar energy, Due to the great abundance of this energy in Iraq, the state of electric energy can improve, Investigating alternative sources of solar energy in Karbala province compared to Erbil province, This study is based on the selection of a photovoltaic system connected to both provinces, with attention was done in latitude and longitude coordinates, An optimal angle for the photovoltaic panel to improve the efficiency of the photovoltaic system in the province.

Kerbal was determined; the results show that the angle of 31 degrees is the best angle of inclination in Kerbal Province.

In this case, it increases the efficiency of the photovoltaic system and provides high performance which will result in a production capacity of 1815 years/kWh, these systems are the main option for relying on renewable energy sources in Karbala, and are considered Iraq.

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