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Baghdad's Solar Power Potential: An Exploration Using PVsyst and HelioScope at Al-Khwarizmi College of Engineering

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Abstract

The energy business has grown explosively over the past few decades because of increased global energy consumption, which has had catastrophic effects on the environment. As a result, the entire planet has begun transitioning to green energy generation, which has zero negative effects on the natural world. Solar electricity has the highest efficiency amongst all forms of renewable energy. This study examines the monthly grid performance of a hypothetical 100 MWp solar facility linked to the Al-Khwarizmi College of Engineering system. Meteonorm 8.0 data are utilised in the simulation, which is run in PVsyst 7.2 and HelioScope software. Maximum energy production is the goal of the simulation, which is implemented at a constant tilt angle throughout the year. The building's latitude is used to set the best angles or an east–west angle that is fixed 10 degrees to the south azimuth. The 3D display in HelioScope allows for a natural, insightful design process, enabling the selection of highly effective design options and the analysis of shading and panel orientation effects. The use of HelioScope and PVsyst software can provide insights into the amount of energy production from solar panels in a specific area. In this work, the amounts of energy generated using PVsyst and HelioScope are 1,500.303 and 849.7653 MWh/year, respectively.

Keywords: *HelioScope software; PVsyst software; Performance ratio; Solar energy*

1. Introduction

Electricity is essential in our daily lives. At present, thermal and hydroelectric power plants generate the majority of electricity. However, renewable energy sources, such as solar and wind power, are becoming increasingly important because of concerns about greenhouse gas emissions and other environmental issues. Numerous nations have established new energy laws that encourage the use of renewable energy sources in the power sector to lower greenhouse gas emissions [1].

Renewable types of energy, especially solar energy, have increased rapidly in recent years and have become an important source of power generation in developed and developing countries. Solar power holds promise because it rapidly expands and provides effective electricity sourced directly from the sun. As energy demands continue to rise, the need to generate electricity by using various energy sources becomes pressing.

With advancements in technology and decreasing costs, solar energy is projected to become a feasible option soon. Solar energy has an advantage over other power sources because it directly transforms sunlight into electricity through solar photovoltaic (PV) cells. Solar power systems are categorised into three types: grid connected, off grid and hybrid systems [1].

Grid-connected PV systems are currently the most common amongst all types. They are linked to a network, typically a public power grid, and supply surplus electricity. These technologies can be employed in decentralised and centralised systems [2].

Many studies have been conducted on solar PV systems to improve the study of solar PV systems, such as that at Al-Khwarizmi College of Engineering (AKCOE). Ranvijay Singh Meena and Savrabh Mishra (2012) described the direct conversion of radiation from a heat source into electrical energy utilising PV cells. The study provided new opportunities for producing environmentally friendly electricity and demonstrated enhanced waste heat energy utilisation [3].

Khadiza Umme Tahera, Raisa Fabiha and Md. Ziaur Rahman Khan (2018) investigated the design of a grid-connected solar PV system for a residence hall at BUET. They calculated the load rooftop area to determine the system size and analysed the system to reduce its reliance on grid power. This solar PV system was modelled after their project [4].

In 2013, V. Tyagi, Nurul A. Rahim, N. Rahim, Jeyraj A. and L. Selvaraj showed how solar cells' commercial efficiency can be increased. Monocrystalline silicon's efficiency increased from 15% in the 1950s to 17% in the 1970s. At present, its efficiency has increased by up to 28%. This study comprehensively examined the development of solar PV technologies and analysed their effectiveness, performance and cost [5].

Mohammad Al-Najideen and Saad S. Alrwashdeh investigated the design of a solar PV system to satisfy the electricity needs of the Engineering Department of Mu'tah University in Jordan. A grid-connected solar PV system with more than 50 kW of power can considerably reduce energy costs by lowering the production and consumption of electricity [6].

The foundation and use of PV solar energy were outlined by Reinders, Verlinden, Sark and Freundlich (2017). In Chapters 1 and 2 of their book, they discussed the fundamental processes of photovoltaics and provided a broad introduction to semiconductor materials and solar cell-related subjects. The application of PV technologies is the focus of the book's second half. PV technologies that are used in space are thoroughly discussed in Chapter 9, and PV modules and their manufacturing procedures are presented in Chapter 10. PV technology applications in systems, buildings and other areas are highlighted in Chapter 11 [7].

Mohammed W. Alhazmi, Yousef Samkari, Mowffaq Oreijah and Ahmed Alnoosani (2018) employed a solar PV system to minimise Umm Al-Qura University's 100 MW power consumption [8].

This study proposes the installation of a solar PV system at AKCOE, recognising the pivotal role that energy plays in the progress of civilisation. Solar energy has elicited much attention as a means to enhance efficiency, mitigate power consumption, curtail carbon emissions and diminish the reliance on fossil fuels. The novelty of this research lies in its focus on integrating the AKCOE system with a theoretical 100 MWp solar project to enable a comprehensive examination of the facility's monthly grid performance.

2. Geographical Location of the Site

AKCOE is a building with five different departments, and it is situated at the University of Baghdad in the heart of Baghdad Province. It is located at longitude 44.3792° E and latitude 33.2723° N. Its temperature ranges from 26 °C to 44 °C in summer and is as low as 10 °C in winter [9]. Therefore, another type of energy, aside from that from fossil fuel, must be used to produce energy. Given that the location of the site and the sun are very high in summer and winter, this site is ideal for setting up the PV power plant for our study.

3. Meteonorm Data

The yearly and monthly climate data used in this project are shown in Table 1. The data are derived using information from Meteonorm 8.0. The table displays the meteorological information and incident energy for the PV system. The worldwide horizontal irradiation (GlobHor) is 1,817 kWh/m^2/year, the horizontal diffuse irradiation (DiffHor) is 857.5 kWh/m^2 and the overall global incident energy on the collector plane is 2,564.7 kWh/m^2.

Table 1,
Information on meteorological conditions and incident energy

Month	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	WindVel m/s	GlobInc kWh/m²	DifSInc kWh/m²	Alb_Inc kWh/m²	DifS_GI ratio
January	94.4	37.9	7.46	1.6	181.0	20.89	4.866	0.00
February	104.8	50.3	10.33	2	166.1	27.23	4.489	0.0
March	146.2	72.6	15.14	2.2	207.8	39.34	4.752	0.0
April	177.2	89.3	19.69	2.2	229.1	45.35	4.214	0.0
May	197.2	102.5	25.76	2.2	239.7	50.98	3.985	0.0
June	219.7	97.2	30.73	2.4	274.2	44.07	4.377	0.0
July	212.2	99.3	34.03	2.5	264.2	46.71	4.276	0.0
August	191.5	94.6	33.50	2.1	241.7	47.03	4.242	0.0
September	167.0	68.9	28.49	1.8	241.5	35.14	4.803	0.0
October	127.3	63.0	23.13	1.6	189.4	33.84	4.926	0.0
November	95.7	44.5	13.96	1.4	169.5	24.41	4.718	0.0
December	83.8	37.2	9.14	1.5	160.4	20.46	4.539	0.0
Year	1,817.0	857.5	21.01	2.0	2,564.7	435.46	54.186	0.0

4. System Layout

The projected plant can generate 100 MWp of electricity in its current form. A solar power plant requires a solar PV module, inverter, mounting structure and cables, meters, switches, fuses and other components. Batteries are not utilised because the solar power plant is linked to the grid. Sixteen modules are used in the system layout, and when they are coupled in sequence, they create 87 strings. We employ east–west dual-axis tracking, which is constant depending on the position of the building; thus, the tilt angle of the PV array is maintained at 10° N to receive the largest amount of solar energy possible. The system's grid connection is shown in Figure 1.

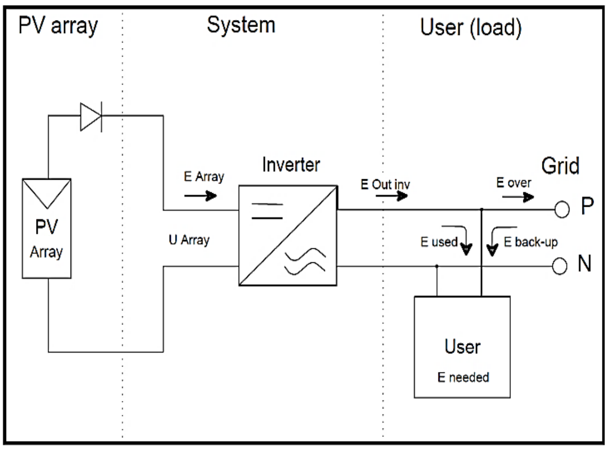

Fig. 1. Grid connection of the system

5. Performance Indicators for Solar Power Plants

5.1 Array Yield

Array yield is sometimes referred to as matrix efficiency and is determined using the nominal power (kWh/kWp/day) and daily DC output energy. The ratio of a PV array's daily, monthly or annual DC energy production to its rated power is known as the array yield [10].

$$Y_A = \frac{E_{DC}}{P_O} \quad \ldots(1)$$

5.2 Reference System Yield

The best array yield determined by nominal power (Pnom) with no loss is called the reference system yield. The reference radiation under a standard temperature condition (STC) is set to 1,000 W/m^2 because each incident kWh should ideally provide the array Pnom for one hour. The available radiation is theoretically normalised to the reference radiation by the incidence energy on the array plane, which is mathematically equivalent to YR. Site location, weather and solar PV panel orientation are all important factors [11].

$$Y_R = \frac{H_t(\mathrm{kWh/m^2})}{I_A(\mathrm{kW/m^2})} \quad \ldots(2)$$

5.3 Final System Yield

The peak power or installed kWp of a PV array at STC divided by the AC energy production of a solar PV system on an annual, monthly or daily basis is known as the ultimate system yield. This yield shows how long a solar PV system must operate at rated power to produce net energy. It is the energy output of the system adjusted for system size. The ultimate yield measures the performance of the solar PV system in terms of the solar radiation resource [12].

$$Y_F = \frac{E_{AC}}{P_P} \quad \ldots (3)$$

5.4 PV Module Efficiency

The efficiency of a PV module may be calculated as [13]

$$\eta_{PV} = \frac{E_{DC}}{G_i * A_{PV}} \times 100\%. \quad \ldots (4)$$

5.5 Efficiency of Inverters

Inverter efficiency is defined as the ratio of the inverter's AC power to the PV array system's DC power. Ref. [14] provided instant inverter efficiency as follows:

$$\eta_{inv} = \frac{P_{AC}}{P_{DC}} \times 100\%. \quad \ldots (5)$$

5.6 PV System Efficiency

The energy generated by a PV array is divided by the entire in-plane solar insolation to determine the overall PV system conversion efficiency, as shown in Ref. [14].

$$\eta_s = \frac{E_{AC}}{G_i * A_{PV}} \times 100\% \quad \ldots (6)$$

The performance of a solar PV plant is influenced by loss characteristics. A solar PV system might lose almost any component that was utilised in its construction. Calculating capture losses is one way to assess the multiple losses in a solar PV plant. Capture losses consist of heat losses. The temperature of the PV module and the loss caused by fluctuating radiation, dust buildup and other elements determine capture losses. Losses in the DC and AC lines are included in the system losses.

5.7 Array Capture Loss

Array capture loss is the difference between the array and reference yields. This loss mostly affects solar arrays and is caused by various factors, such as rising PV cell temperatures, partial shadowing and dust building in photovoltaic arrays, maximum power point errors and mismatches. Another term for it is collection loss [15].

$$L_A = Y_R - Y_A \quad \ldots (7)$$

5.8 System Loss

System loss is the variation between system and array yields. Examples include battery inefficiencies in standalone systems and inverter losses in grid-connected systems [16].

$$L_s = Y_A - Y_F \quad \ldots (8)$$

6. Methodology

In this study, the solar energy generation potential of placing PV panels on the roofs of college buildings was calculated using PVsyst and HelioScope. The optimal panel position was determined with the HelioScope algorithm. We began by specifying the longitude and latitude coordinates of the desired site. The software acquired meteorological data from Meteonorm, a global provider of historical, current and forecasted climate data. For its efforts in solar energy, renewable energy, urban planning, architecture and environmental impact assessments, Meteonorm has received much appreciation [15].

The tilt and azimuth angles were chosen to specify the panels' orientation. Tilt angle is the degree of inclination of a solar panel or PV module concerning a horizontal surface. This setting has a considerable influence on the panel's ability to capture energy. Given that the tilt angle affects the quantity of sunshine the panels receive throughout the year, it is crucial in optimising the energy production of a solar system. Solar installations employ many types of tilt angles, but inclination angle tracking is often used. Tilt angle tracking involves solar tracking systems that continually alter the inclination of solar panels during the day to face the sun directly. Solar tracking systems are classified into two types.

a. Single-axis Tracking: During the day, panels are adjusted along one axis (either horizontally or vertically) to track the sun's east–west movement. This tracking method is simpler and less costly than dual-axis tracking, but it provides less exact solar tracking.

b. Dual-axis Tracking: Panels are adjusted along horizontal and vertical axes, allowing them to track the movement of the sun in azimuth (east–west) and elevation (up–down) directions. Dual-axis tracking systems are sophisticated and expensive, but they catch and use the most solar energy.

Tilt angle tracking is more expensive to install and need more maintenance than permanent or seasonal tilt systems, even though they may substantially increase the energy output. The location of the installation, the available budget, the amount of energy required, the desired degree of solar energy collection and the efficiency of the system influence the tilt angle that is employed. However, we found that the best method to maximise the tilt angle in the setting of our research, which focuses on public places, is east–west tracking. The solar panels' orientation with respect to the cardinal directions is known as the east–west angle. In this instance, the panels are slightly slanted east of due south after being fixed 10° to the south azimuth. This angle was chosen in this study for the following reasons:

1. Maximising Daily Energy Production: Tilting the panels slightly to the east allows for early sun exposure in the morning. This situation implies that the generation of energy starts at a certain time in the day, allowing the solar panels to harness sunlight, especially in the morning when the sun is positioned low in the sky.
2. Evening Energy Generation: Although angling towards the east may result in a decrease in captured energy at midday when the sun is at its highest position, it helps prolong energy generation into the late afternoon. This situation could be advantageous for fulfilling energy needs in the day.

The choice of an east–west orientation, such as a fixed tilt angle, serves as a balance to enhance the energy output all year round. This setup ensures energy production throughout the day and across seasons, thus offering benefits for grid integration and effective load management.

In summary, the decision to maintain a consistent tilt angle all year round and a set east–west angle southward is based on practicality and the goal of balancing energy generation throughout the times of the day and seasons. These selections can be tailored to suit locations and energy generation objectives, with the overarching aim of optimising the operation and cost efficiency of the solar PV system.

The azimuth angle refers to the angle between the direction of the true south and the tilt angle of the solar panel. The solar cell must face true south to capture the most sunlight. As a result, an azimuth angle of (0) corresponds to the ideal orientation, which is directly facing south.

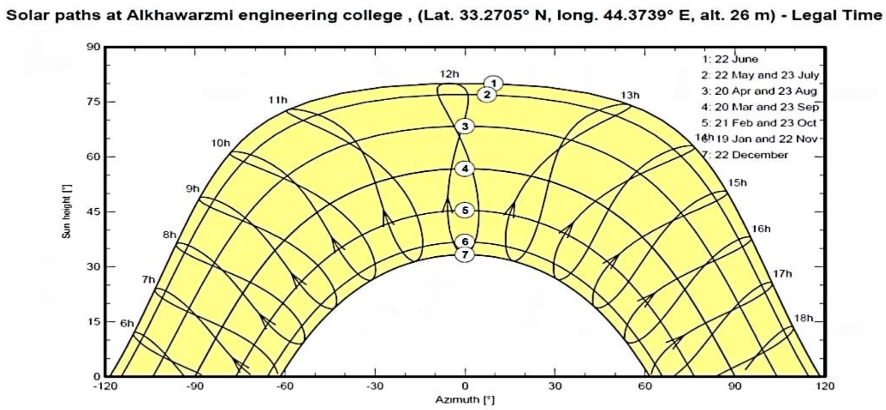

Fig. 2. Sun path at AKCOE

Figure 2 depicts the sun's path in Baghdad throughout the year and the related solar radiation levels. It shows that the longest day is June 22, with 15 hours of sunshine and just 9 hours of darkness. The shortest day is December 22, with 10 hours of sunshine and 14 hours of darkness. This difference is caused by the sun's high position in summer and its low position in winter.

Next, we selected the components of our system. We had the option of selecting either the required power output or the application area. PVsyst and HelioScope provide vast databases covering numerous types of solar panels and inverters from various manufacturers, allowing us to pick the most appropriate ones. We chose Ginko Solar Company's solar panels for this project because they are known for their high quality and efficiency. Under STC, these panels have a maximum power capacity of 610 Wp and a maximum power voltage (Vmp) of 45.25 V, with a module efficiency of 21.46% [18]. An inverter is needed to convert DC from solar panels to AC.

To complete our arrangement, we selected an SMA Company inverter with a nominal PV power of 100 kW and a maximum efficiency of 98.80% [19]. Figures 3 and 4 illustrate all of the details and the shading effects.

Fig. 3. Implementation of rooftop solar panels and assessement of their susceptibility to shading through HelioScope software

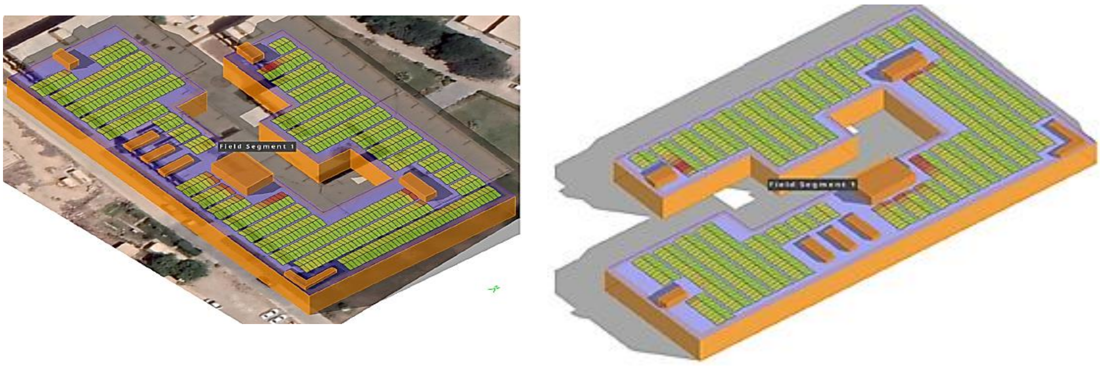

Fig. 4. Examination of the building's views, with the left part capturing the southeastern perspective and the right part depicting the southwestern outlook. Such examination is facilitated by HelioScope software

7. Results

7.1 PVsyst Software

The proposed PV system's simulation results were analysed. The project's needs and limitations are reflected in PVsyst, where the system's production of 100 MW/month using monocrystalline solar cells is displayed. Produced energy, specific production and performance ratio were the key production factors in this simulation. The findings were used to assess the monocrystalline PV system's performance.

7.1.1 Mostly Generated Energy

Table 2 displays the balances and important results of a grid-connected PV system. The yearly average horizontal irradiance for the entire planet is 1,817 kWh/m². The yearly incident energy of the collecting plane is 2,564.7 kWh/m².h. In June, 141,343 kWh was the largest amount of energy injected into the system. In December, 102,481 kWh was the least amount of energy introduced into the system. Annually, 1,500,303 kWh of energy is injected into the grid. The outdoor temperature is 21.01 °C on the average.

Two parameters were evaluated based on the primary simulation findings. The first parameter was the total quantity of energy generated every year by the system of monocrystalline solar panels, which is referred to as produced energy (1,500,303 kWh/year). The average performance ratio (PR), which is the second parameter, for the year is 86.86%.

Table 2,
Balances and main results

Month	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh/m²	E_Grid kWh	PR Ratio
January	94.4	37.9	7.46	181.0	144.3	116,402	114,511	0.923
February	104.8	50.3	10.33	166.1	137.4	109,629	107,859	0.911
March	146.2	72.6	15.14	207.8	167.6	131,071	128,977	0.890
April	177.2	89.3	19.69	229.1	180.6	138,824	136,628	0.874
May	197.2	102.5	25.76	239.7	182.7	137,626	135,509	0.854
June	219.7	97.2	30.73	274.2	194.8	143,519	141,343	0.834
July	212.2	99.3	34.03	264.2	192.1	140,200	138,110	0.827
August	191.5	94.6	33.50	241.7	187.7	137,044	135,003	0.830
September	167.0	68.9	28.49	241.5	186.1	137,634	135,526	0.842
October	127.3	63.0	23.13	189.4	157.5	119,692	117,860	0.868
November	95.7	44.5	13.96	169.5	136.9	108,190	106,496	0.903
December	83.8	37.2	9.14	160.4	129.4	104,151	102,481	0.921
Year	1,817.0	857.5	21.01	2,564.7	1,997.1	1,523,983	1,500,303	0.869

Note: GlobHoris is horizontal global irradiation, DiffHor is horizontal diffuse irradiation, T_Amb is ambient temperature, Glob Inc is the global energy incident on the plane, GlobEff is the effective global energy corresponding to IAM and shadings, EArray is the effective energy at the output of the array; E_Grid is the energy injected into the grid and PR is the performance ratio.

7.1.2 PR

A PV plant's quality is evaluated using PR, a quality factor. PR illustrates the relationship between the theoretical and actual energy production of PV installation. After accounting for energy losses and consumption, PR displays the amount of energy. The losses include damage to the solar panel, loss of the inclination angle, damage from dust, damage from shadows and damage from changes in module temperature. PR is often around 80% because of inevitable operational losses. If PR reaches 80%, the technique will become increasingly effective and successful. On an annual basis, PR is used to assess how well solar power plants operate.

Figure 5 displays the incident energy PR for each month of the year. PR is 0.869 on the average.

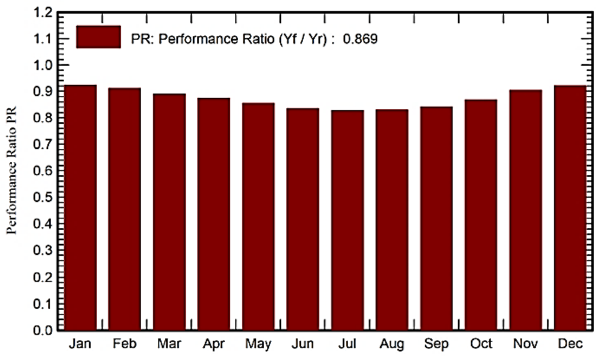

Fig. 5. Performance ratio (%)

7.1.3 Normalised Production

Figure 6 depicts the normalised output of PV power facilities. It shows PV array collection losses, system losses and usable energy generated by inverter output. It also indicates the monthly output and kWh losses.

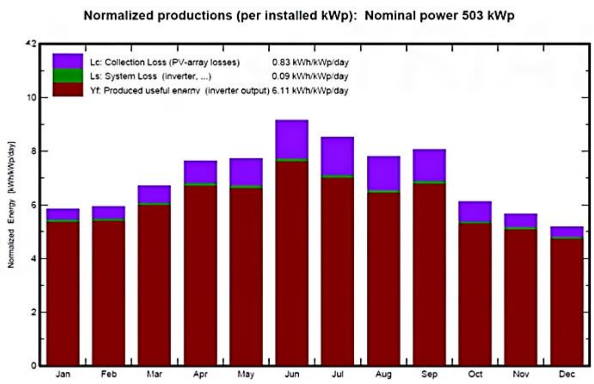

Fig. 6. Monthly nominal power graph

Figure 6 shows that the annual average daily energy output (Y_F) is 6.11 kWh, the collection loss (L_c) is 0.83 kWh and the system or inverter loss (L_s) is 0.09 kWh.

7.1.4 System Losses

The specific monthly average system losses are displayed in kWh in Table 3. The yearly module quality loss (Mod Qual) is 8,803.34 kWh. The mismatch loss (Mis Loss) per module each year is 25,426 kWh. The ohmic wiring loss (Ohm Loss) for a year is 13,846 kWh. The virtual energy of the array at the maximum power point (MPP) is known as EArrMPP. The inverter loss for the entire year is 21,103 kWh.

Table 3,
Detailed system losses

Month	Mod Qual kWh	Mis Loss kWh	Ohm Loss kWh	EArrMPP kWh	InvLoss kWh
January	−656.680	1,897	973	85,345	1,327
February	−596.769	1,724	855	77,587	1,182
March	−732.644	2,116	1,089	95,213	1,425
April	−794.561	2,295	1,238	103,203	1,544
May	−811.558	2,344	1,288	105,387	1,762
June	−908.879	2,625	1,579	117,889	2,686
July	−867.306	2,505	1,467	112,536	2,976
August	−796.124	2,299	1,310	103,337	2,507
September	−807.814	2,333	1,380	104,803	2,051
October	−648.924	1,874	975	84,323	1,307
November	−602.420	1,740	866	78,320	1,172
December	−579.666	1,675	826	75,368	1,163
Year	−8,803.345	25,426	13,846	1,143,311	21,103

The total system loss diagram for the AKCOE site is shown in Figure 7. The worldwide horizontal irradiation is 1,817 kWh/m². The effective irradiation on the collecting plane is 1,997 kWh/m². The PV cell converts the solar energy into electrical energy. The nominal energy of the array after PV conversion is 1,696,963 kWh. Under (STC, the PV array's efficiency is 21.84%. The virtual energy received from the array is 1,523,653 kWh. In the inverter output, the available energy after inverter failure is 1,500,303 kWh.

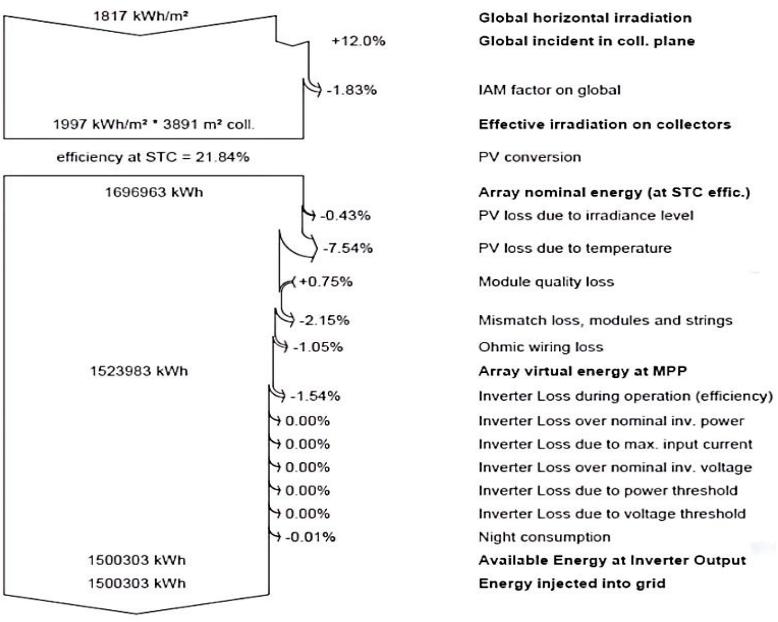

Fig. 7. Sources of system loss in PVsyst software

7.2 HelioScope Software

7.2.1 Energy Generated in the System

Figure 8 depicts the energy-generating ranges in the HelioScope software system. HelioScope software systems have an average annual ambient temperature of 24.4 °C. HelioScope, a modelling tool, generates 849,765.3 kWh on the average per year. Table 4 displays grid energy, panel energy, plan of array (POA), shaded irradiance and global horizontal irradiance (GHI). GHI, which is the total amount of light that a square meter on the ground receives, is measured in this case. The solar irradiance used in POA is a combination of albedo (irradiation reflected by the earth) and diffuse irradiance.

The direct irradiance on a panel or POA is solar irradiation multiplied by the cosine of the angle of incidence (the angle between the sun's direction and a panel-normal vector).

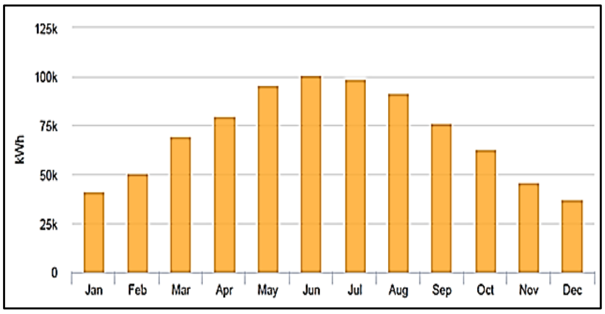

Fig. 8. Monthly energy prediction using HelioScope software

Table 4,
Monthly prediction using HelioScope software

Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	92.8	92.6	91.7	45,100.7	41,640.1
February	112.9	112.9	111.5	55,451.1	50,735.1
March	157.0	156.4	154.9	77,704.7	69,706.2
April	180.6	197.7	178.3	89,771.0	79,645.1
May	221.3	220.2	218.6	110,507.8	95,683.0
June	236.8	235.7	233.5	118,340.9	100,399.4
July	234.7	233.6	231.7	117,330.7	98,715.1
August	218.3	217.1	215.7	109,038.3	91,689.7
September	179.8	179.2	177.4	89,321.6	76,340.6
October	144.9	144.3	143.3	71,545.4	62,534.5
November	103.5	103.2	102.1	50,389.0	45,450.4
December	84.0	83.8	82.8	40,591.1	37,226.1

AKCOE's flat roof has certain trammels, such as a cooling room and a water container, because the area of the roof is close to 5,508 m^2. The structure can only accommodate 870 solar panels; thus, we chose 610 W panels. The total energy produced by these panels is 849,765.3 kWh.

7.2.2 System Losses

Many losses occurred during the installation and operation of the system. Figure 9 depicts various losses, such as AC system losses (losses after inverters) and soiling losses (losses caused by contaminants, such as dust).

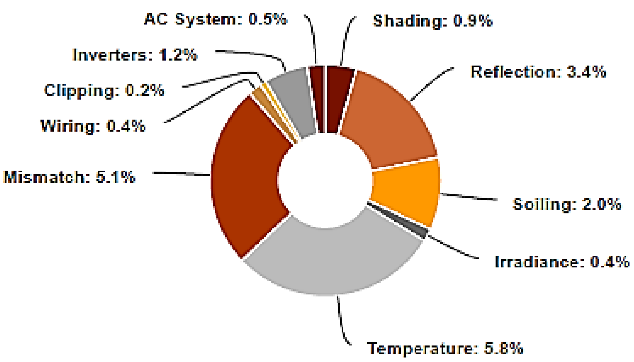

Fig. 9. Sources of system loss in HelioScope software

The actual energy spent in AKCOE is 935,470.295 kWh, and the energy produced by the PV system is nearly 1,500,303 kWh/year. Hence, it is useful to employ the PV system instead of electricity from the burning of fossil fuel.

8. Discussion

Using PVsyst and HelioScope software in a project allows for a full, detailed evaluation of PV system performance and design. These software programs are useful tools in the solar energy business because they help increase the efficiency and production of solar power plants.

PVsyst is a well-known reliable software that allows users to model and simulate PV systems. It offers detailed information on solar irradiance, shading, system losses and energy output estimates via a number of functions. To use PVsyst for a project, customers must provide the geographical location of the project, PV module characteristics, PV array orientation and inclination. PVsyst also uses weather data from Meteonorm to provide a realistic simulation of system performance over time. Analysing the energy output and system losses allows for adjustments to PV system design to increase energy generation and overall efficiency.

HelioScope is a software tool that is beneficial for developing and improving PV system architectures. It offers 3D modelling and visualisation tools to help determine the effect of shade and panel orientation on energy generation. HelioScope allows users to easily determine the best design for PV panels by specifying the location, tilt and azimuth angles. This tool also enables users to compare different array installation alternatives, such as rooftop or ground-mounted arrays, while considering factors, such as sun-path and shading diagrams.

In the design of a PV system, PVsyst and HelioScope must be utilised. PVsyst allows users to accurately predict the energy output on the basis of weather and system conditions. Meanwhile, HelioScope aids in the design phase by determining the effects of panel placement and shading. These software packages allow users to identify design flaws and improve architecture for maximum energy production and efficiency.

Furthermore, these software packages have simulation tools that enable project teams to perform sensitivity analyses, which allow them to assess the effects of different factors on system performance. For example, changes made to the panel type, inverter selection or system orientation may be examined quickly. This procedure provides vital insights into the most cost-effective and efficient combinations.

In summary, the use of PVsyst and HelioScope in projects provides designers and developers with the knowledge they need to make educated decisions, optimise PV system layouts and achieve high energy output and ROI. These software tools are crucial for solar project design and implementation and assist in the progress and broad usage of renewable energy technology.

9. Conclusions

Energy yield analysis for 1,500 MW of PV power was conducted using PVsyst modelling software. The geographical location of Baghdad University, which is situated at 33.2723° N and 44.3792° E, was used for solar power generation. Around 87% of PR was attributed to performance, and 1,500 MW of power was produced. It was possible to create as much electricity by installing roughly 100 MW each month. This study discussed the technical and financial viability of a grid-connected 100 MW solar PV energy-producing plant at the University of Baghdad as well as design modelling and simulation. The monocrystalline PV system's average PR in the simulation of the planned site was 87%. This system accounted for almost 90% of the overall power use in AKCOE at the University of Baghdad.

HelioScope provided us a 3D representation of the layout of our PV system, thereby allowing us to evaluate the effects of shading and panel orientation. By exploring location options, such as rooftop and ground installations, we obtained insights into optimal design choices. The user-friendly interface and advanced visualisation tools of HelioScope enabled us to engage in an insightful design process.

Overall, the incorporation of PVsyst and HelioScope into our project improved the precision and efficacy of our design process and deepened our understanding of solar energy technology. We were able to create a high-performance, well-optimised solar energy system by using the capabilities of these software tools, thus contributing to a clean, sustainable future. The usage of these tools increased the success of our specific project. These results highlight the need for cutting-edge simulation and modelling software in the development of renewable energy technologies.

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إمكانات الطاقة الشمسية في بغداد: استكشاف باستخدام برنامج PVsyst وHelioscope في كلية الهندسة الخوارزمي

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المستخلص

على مدى العقود القليلة الماضية، أدى ارتفاع الطلب العالمي على الطاقة إلى نشوء نمو هائل في قطاع الطاقة، وما ترتب على ذلك من عواقب وخيمة على البيئة. ونتيجة لذلك، بدأ الكوكب بأكمله في التحول إلى توليد الطاقة الخضراء، والتي ليس لها أي آثار سلبية على العالم الطبيعي. تتمتع الكهرباء الشمسية بأعلى كفاءة مقارنة بأشكال الطاقة المتجددة الأخرى. تتناول هذه الدراسة أداء الشبكة الشهرية لمنشأة طاقة شمسية افتراضية بقدرة 100 ميجاوات مرتبطة بنظام كلية الخوارزمي للهندسة. يتم استخدام بيانات Meteonorm 8.0 في المحاكاة التي يتم تشغيلها في برنامج PVsyst 7.2 وبرنامج Heliscope. إن الحد الأقصى لإنتاج الطاقة هو هدف المحاكاة، والتي يتم تشغيلها بزاوية ميل ثابتة على مدار العام. يتم استخدام خط عرض المبنى لتحديد أفضل الزوايا أو الزاوية الشرقية والغربية والتي تكون ثابتة بمقدار 10 درجات إلى السمت الجنوبي. ومع ذلك، فإن العرض ثلاثي الأبعاد في HelioScopeسمح بعملية تصميم أكثر طبيعية وثاقبة، مما أدى بدوره إلى اختيار خيارات التصميم الأكثر فعالية وتحليل تأثيرات التظليل واتجاه اللوحة. وأخيرًا، سيساعدنا استخدام برنامجي Heliscope و PVsyst في الحصول على رؤية مستقبلية لكمية إنتاج الطاقة من الألواح الشمسية في منطقة معينة.