International Journal of Computational and Experimental Science and ENgineering
(IJCESEN)
Vol. 11-No.3 (2025) pp. 4081-4093
http://www.ijcesen.com
Research Article
ISSN: 2149-9144

Designing a Solar City Using Solar Energy to Generate Energy through Innovative Planning and Energy Simulation System (Kufa University Case Study)

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Article Info:

DOI: 10.22399/ijcesen.2686
Received : 21 February 2025
Accepted : 25 May 2025

Keywords

Innovative Planning
Solar Radiation
Solar Energy
Simulated Solar Energy System
Environment
Sustainability

Abstract:

The research indicates the possibility of using solar radiation and its role in generating electricity through photovoltaic solar systems that do not emit environmental pollutants. To solve the problem of generating electric power from fossil fuels that pollute the environment, the study was conducted to answer the following questions: Do solar energy projects have the potential to preserve and sustain the environment? And is there an economic advantage compared to energy sources generated from fossil fuels? Climate characteristics have an impact on production efficiency and increase in electrical energy consumption, and there is a relationship between climatic characteristics and solar radiation, as well as between electric energy produced and climatic characteristics. Because the University of Kufa is one of the first universities to use solar renewable energy in its corridors, it was important to shed light on this aspect for its sustainability in the field of energy. Through the research, we found that the University of Kufa is qualified to be a solar city that produces enough energy and even a surplus to serve its neighboring regions by providing them with produced electric energy. It was found from the feasibility study conducted for the project in terms of cost, system lifespan, and its location within the university's borders that it is the right place for installing solar systems. Many of the electric towers are located inside the university, facilitating the process of connecting them to the governmental electricity grid. Thus, it is considered a support and backing for governmental electricity.

1. Introduction

The research deals with solar energy as one of the important sources of renewable energies available in Iraq, which can be used to generate electricity instead of generating electricity from burning gas and other sources that pollute the environment and are far from sustainable. We will be introduced to the origins of the solar city, which is one of the renewable energy cities and is considered the offspring of the smart city that used innovative planning as a tool to achieve the character of smartening cities. From there, we reach sustainable, environmentally friendly cities. The study then addresses the characteristics of the climatic study area and the amount of solar radiation reaching it in the winter and summer. The design of networks is carried out using a solar energy simulation program, employing photovoltaic cells that move with solar radiation, and selecting the hybrid system as a starting point for the design. Statistical analysis and mathematical equations are then used to convert solar radiation into solar energy.

2. Research Limitations

2.1 Temporal limits

The study covers the period from 2018 to 2021.

2.2 Spatial boundaries

Knowing the geographical location is important to understand the solar radiation to the area and what can be generated from electric power through solar energy. The study area, the University of Kufa, is located between longitude [X] and latitude [Y], that is, it is located between Airports Street on the right and the city of Kufa on the left.

2.3 Objective limits

The research focuses on studying solar energy and its outputs in the generation of electric power because it is clean and environmentally friendly. A solar city was planned at the University of Kufa by relying on solar energy.

3. Previous and Similar Studies

Knowing the previous studies is important because it helps us understand the subject and gives a comprehensive idea about the nature of the phenomenon to be studied.

3.1 Ala' Raheem Mohammed Jawad Al-Shimari's study

"Calculating the amount of electrical energy generated by solar radiation in Iraq." The researcher concluded that there are differences in the values of solar radiation, theoretical and actual brightness hours, and the amount of electrical energy in terms of voltage and current. The highest indicator of electric current reached 6,699 amps per year in Najaf station, and the lowest indicator of electric current reached 5,708.7 amps per year in Mosul station. The study showed the need to take advantage of the available possibilities of electrical energy generated from solar radiation. The highest degree of voltage generated by solar radiation was 73,132.5 volts annually in the Najaf station, while the Mosul station recorded the lowest degree of voltage at 71,892 volts annually [1].

3.2 Alaa Shalal Farhan Hassan Al-Fahdawi's study

"The potentials of Anbar Governorate from solar radiation and its role in the development of alternative energy." In his thesis, the researcher emphasized the difference in the amount of solar radiation during a period of 30 years to record climatic variables. Its location within vast desert areas that the influence of the seas does not reach has earned it a surplus of solar radiation that increases as we head towards the south. The study also identifies areas that can be used to build solar complexes to produce electrical energy [2].

3.3 The study of Ryan Murray and others

"A Proposal for a Solar Deployment for the University of Kansas." This project is designed to propose a plan for the installation of solar panels for the University of Kansas. The panels will be installed on the planned new student residences in Daisy Hill. This would be a suitable location for a solar array where the panels can be installed alongside the building rather than being modified to fit existing buildings. The site is an ideal location based on exposure to sunlight [3].

4. The Concept of Innovative Planning

Planning is an organized scientific method for a series of interrelated and successive processes to reach certain goals and objectives through a determined strategy within a period of time. Researchers describe planning as a comprehensive process for all aspects of human life that aims to conduct a precise and continuous organization that allows resorting to the best available means to achieve certain goals or objectives. Thus, it includes the economical exploitation of economic resources. It is not possible to give an accurate definition of planning because of the different fields of researchers who are looking into it, the different environments, and the different existing political systems. Planning is a scientific method for thinking about the existence of a problem that is studied and alternatives are developed for it from compared directions and solutions to choose the best to achieve the planning goals. It begins with a vision and ends with a project to achieve the goals and fulfill the vision. Planning is described as a connected and continuous process that aims to devise appropriate ways to control the spatial management system through a set of innovative solutions to multiple spatial problems. The planning process works on the principle of raising efficiency, exploiting the resources of society through the new innovation of scientific methods in discovering and using resources in an optimal manner, and ensuring the operation of idle, lagging, or undetected productive capacities to raise the productive efficiency of existing economic units. It also preserves the productive elements and avoids wasting resources. The energy of the place represents the direction of development and the achievement of well-being. Because the areas of technological progress and globalization have created new variables at the spatial and temporal levels, the adoption of the innovative planning approach, which is the modern style of planning patterns, has become a necessity that must be exploited to keep pace with technical developments. This approach develops radical and immediate solutions to the most prominent spatial problems through an intelligent approach that works on the optimal use of resources and their proper employment. This leads to the sustainability of the place and improves the quality of life within a specified period of time. It also follows up and

monitors the effects of the desired development and the transition of societies from the idea of traditional planning to the idea of intelligent and innovative planning.
Innovative planning depends on a set of tools and procedures that ensure the achievement of the principle of sustainability. Because the conditions and criteria for sustainability assume the principle of adopting technological development and innovation and developing smart solutions in determining the requirements and alternatives for planning cities and regions, it has become necessary to study the spatial and temporal variables according to a planning approach based on the use of these variables to reach the state of the smart city. Smart cities, in addition to being one of the most important products of innovative planning, achieve the principle of sustainability by creating a set of savings and advantages that enable these cities to use information and communication technology and other means to improve urban operational efficiency, services, quality of life, and competitiveness. They also ensure that they meet the needs of present and future generations in terms of economic, environmental, and social aspects. The inevitability of adopting the principle of innovative planning was not purely a coincidence for the authorities responsible for planning, but rather an attempt by them to support the successful requirements of the planning process on a large scale. This aims to overcome the weaknesses and deficiencies that impede the success of the planning process. Planning, as a process, depends on a set of solutions and alternatives for the purpose of facing challenges at the spatial level, but it is also concerned with overcoming traditional considerations in developing and proposing planning solutions and alternatives. This is achieved by opening up to new and smart methods in achieving the objectives of the planning process with less cost and higher benefits and more accurate results.
Thus, innovative planning requires the existence of innovative smart solutions. We find that the innovative planning work is based on three elements as its basis: research, development, and marketing [4].

4.1 The Role of Innovation in Planning Can Be Determined Through The Following Areas

1. Planning product: It means a set of innovative tools in the planning process
2. Planning process origin: is the use of innovative techniques to create methods, ways and models for intelligent planning.
3. Service level: is to provide the people with the services they need to raise their life quality.
4. Innovation in business model: It means the basics in the economies of cities and with distinct models.

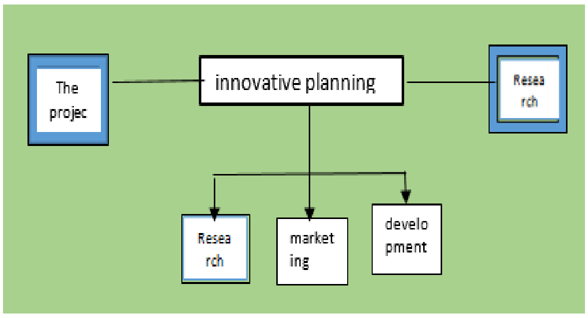


Figure 1. *The Three Elements of Innovative Planning (Al Basrry 2020)*

4.2 Justifications For Innovative Planning

Science, innovation and technology can be employed in achieving sustainable urban development by taking into account the economic, social and environmental indicators after the apparent failure of the various tools adopted by the traditional planning, which could not face the intractable problems of the challenge and urban encroachment in general. Consequently, it led to resorting to the innovative planning approach. Examples of these are the following:

First: the population increase, which was considered an alarm bell for cities.
Second: The lack of successful plans in facing the issues of random urban expansion.
Third: the transportation and movement crisis.
Fourth: pressure on infrastructure systems.
Fifth: Increasing resource consumption of all kinds.
Sixth: The growing environmental problems and the various emissions and pollution problems.
Seventh: The need for spatial tools that serve urban planning.
Eighth: Lack of rationalization and change of consumption patterns.
Ninth: The need for new ways and methods in urban planning and governance.
Tenth: Lack of knowledge and innovation to sum what is known as the knowledge economy and idea economy Innovation-based and its role in protecting sustainable urban development and determining a desirable level within peace economy of cities and regions [5].
From the foregoing, we see that energy consumption is one of the justifications for using innovative planning, through which renewable energy can be used in order to reduce the pollution

that other resources do to the environment. As well as making use of renewable energies in order to achieve sustainability and ensure the right of future generations.

5. Renewable Energy Solar Cities

5.1 What Is a Solar City?

The Solar City aims at minimum 10% reduction in projected demand of conventional energy at the end of five years, through a combination of enhancing supply from renewable energy sources in the city and energy efficiency measures [6].
So the concept of the solar city is that it is a city that depends on the production of its electrical energy from solar energy, so it is considered one of the cities of renewable energy, which depends on smarting the building to achieve the principle of sustainability. And the most important climatic element for them is solar radiation. These cities can be built in areas that contain high solar radiation and depend on techniques for converting solar energy into electrical energy. The solar city is among the cities with renewable energy and environmentally friendly cities. By using intelligence, justice, calculating the economic cost and serving its residents, you have achieved the principle of smart sustainable cities [7].
The first principle of building smartness relates to the flexibility of using the surfaces of buildings to take full advantage of the Alternative energies, including solar energy. As for the second principle, when adopting alternative energy for buildings, it provides 80% of the total energy demand over a period of time ranging from 20 years up to 45 years [7].

5.2 Solar Energy

Electrical energy is generated from solar energy by thermomechanical engines or photovoltaic converters. These technologies are known as positive energy systems, converting solar energy into another form that may not be electrical, such as distillation and purification of water to be potable, or the exploitation of daylight, hot water, and high temperatures for industrial purposes. And even the use of heat energy in cooking or storage of heat energy for later use. On the other hand, passive energy systems include techniques that rely on the exploitation of solar energy by directing a building towards the sun, choosing materials with the appropriate thermal mass or light ray scattering properties, and designing spaces that naturally circulate the air [9].

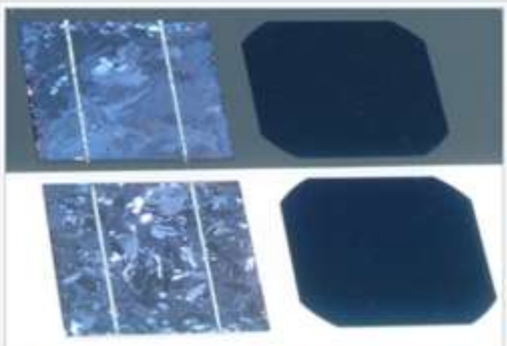
5.3 Solar Cells

Solar cells are photovoltaic converters that convert direct sunlight into electricity, It is a semiconductor, photosensitive, and surrounded by an electrically conductive front and back sheath. Many technologies have been developed for the production of solar cells through sequential chemical, physical and electrical treatments in the form of a self-condensing or highly automated, and various materials have been developed for the manufacture of solar cells in the form of elements such as silicon sulfide, gallium, cadmium, zirconium and zirconium compounds as compounds Copper and other promising materials for the photovoltaic industry [10].

5.4 Types Of Commercial Solar Cells

5.5 Crystallized Silicon Solar Cells:

Crystalline silicon (c-Si) is the crystalline forms of silicon, either polycrystalline silicon (poly-Si, consisting of small crystals), or monocrystalline silicon (mono-Si, a continuous crystal). Crystalline silicon is the dominant semiconducting material used in photovoltaic technology for the production of solar cells. These cells are assembled into solar panels as part of a photovoltaic system to generate solar power from sunlight.
These cells are made of silicon by growing silicon rods, sintered into wafers, then chemically and physically treated through different stages to reach solar cells. The efficiency of these cells is high, ranging between 9-17%, and monocrystalline silicon cells are expensive because of the difficulty of technology and energy consumption, while silicon cells are polycrystalline, it is less expensive than monocrystalline and also less efficient [11].


Crystalline-silicon solar cells are made of either poly-Si (left) or mono-Si (right)

5.6 Amorphous Silicon Solar Cells

The material of these cells is silicon in shape, where the crystal formation is cracked due to the presence of hydrogen or other elements that were intentionally introduced to give them distinctive electrical properties. The efficiency of the cells of this material ranges between 4-9% for a large surface area and slightly more than that for a small surface area, although its stability is affected by solar radiation [12].

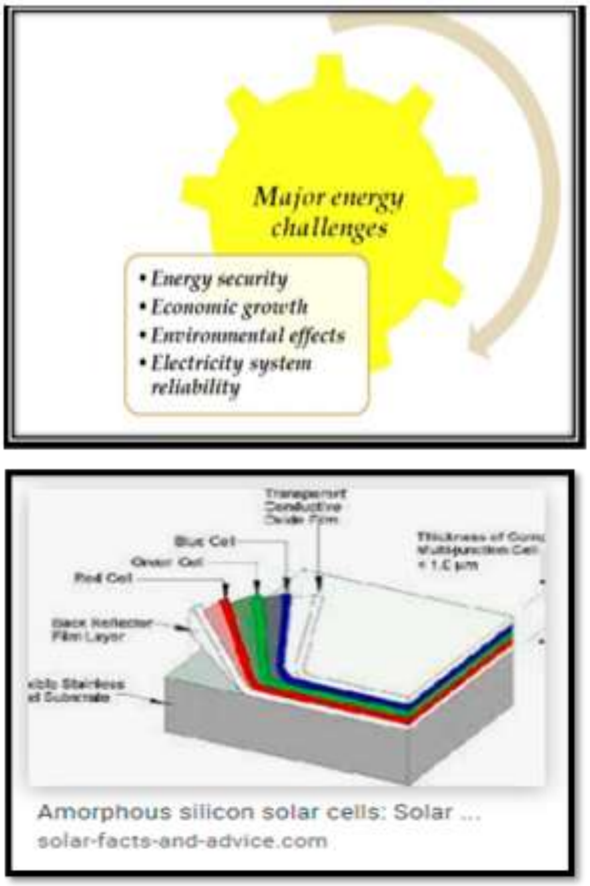


Figure 2. *Illustrating the energy challenges (Bacioglu, 2017)*

Energy is one of the most important human needs in his daily life, as energy is of great importance and becomes increasingly vital with the gradual advancement of technology [13].
Through Figure (2) we conclude:

1. Energy Security: Energy resources must be available for the future and be guaranteed to future generations
2. Economic growth: is the provision of energy needs in developing countries.
3. Environmental impact: The effects associated with the processes of artificial energy conversion on environmental energy.
4. Providing electricity: It is the integration of the electric energy infrastructure and its ability to provide continuous electric energy with high quality.

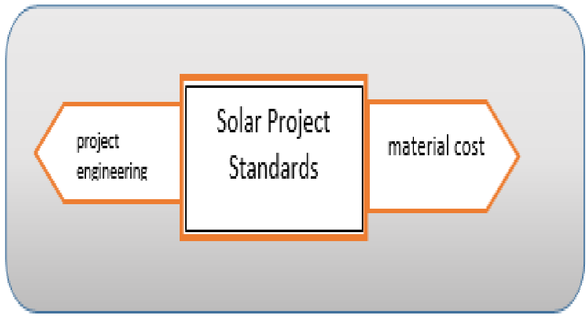


Figure (3) Solar Standards (Maria , Maria)Johan and Carmel, 2017

Figure 3. *Solar Standards (Maria, Maria, Johan and Cammel, 2017)*

6. PV System

6.1 What Is PV System's Design?

Solar PV modules are where electricity is generated, but it is only one of many parts in a complete photovoltaic (PV) system. For the electricity generated to be useful in the home or business, there must be a number of other technologies.
It is one of the photovoltaic simulation programs that are used to design photovoltaic solar energy systems around the world that operate on photovoltaic cells. The program was produced in Switzerland. It was then developed by Swiss physicist Mermoud Andre and electrical engineer Villoz Michel [14].
This program is considered a standard for designing a simulation system for the production steps of any project around the world, this program is designed to be used by engineers, researchers and students. The rapid estimation of production at the project planning stage, hourly estimation, detailed study, reporting and scaling are its main features. The software is a handy design tool for PV system estimation. It simulates most of the information required by PV system designers, and helps in creating a comprehensive simulation report that allows a high degree of control over various factors [15].

6.2 A Toolbar Shows When Opening The Program as Follows

1. File
2. preliminary design
3. project design
4. settings language
5. language
6. License
7. Help

Figure 4. *Interface of program by PV system (www.google.com)*

6.3 Design By Networking

It is the transfer of energy by inverters to the user and the injection of the remaining energy into the local electrical network. This is done by smart meters to find out the user's need and energy surplus, then specify the project name and project location in order to know the climatic characteristics of the area in question. As shown in (Figure 5).

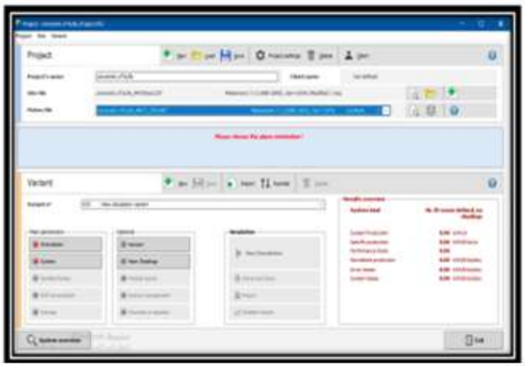


Figure 5. *The gerographical location of the study area by pv s (www.google.com (researcher))*

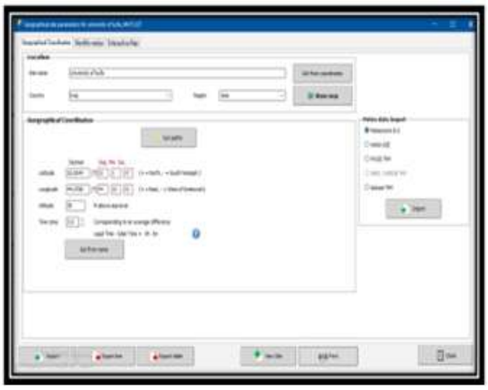


Figure 6. *Determining the name of the project by PV s (www.google.com (researcher))*

When determining the study area, the program gives the longitude, latitude and altitude above sea level as shown in (Figure 6)
Through the same tab, the source of climate data is chosen, where three options are available,
1-Metenorm , 2-Nasa-sse , 3-PvGis TMY

Figure (7) Climatic data available in pv system researcher)

Figure 7. *Climatic data available in pv system (researcher)*

The best source for providing all climate data is what Metenorm provides, as it provides rates of climate data from solar radiation, temperature, humidity and wind speed for the year 1998-2000.
It is also possible to enter modern data approved by the Department of Meteorology and Seismic Monitoring in Iraq for the study area to make the results more accurate as shown in (Figure 7)

6.4 Define The Orientation of The Panels

The angle and direction of the panels are chosen according to the summer or winter seasons in order to obtain the least energy loss. The type of panels can be chosen fixed or mobile with the movement of solar radiation to the area as shown in (Figure 8)

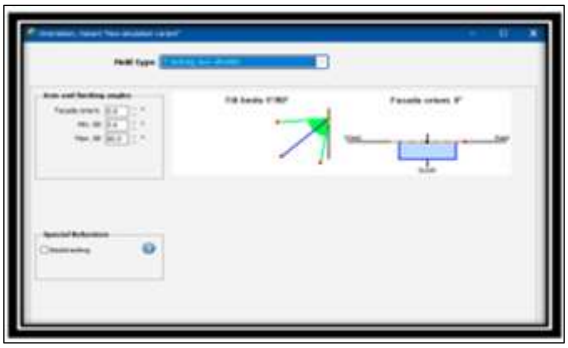


Figure 8. *Choosing the type of solar panels moving with the sun beam (researcher) by PV S*

6.5 Solar Project System

The building area or the available space, the type of solar panels and the type of inverter are entered. The program calculates the solar energy provided by the input area, the number of panels and the number of inverters, and by entering the area of university buildings, the program determines the amount of energy that will be provided by the input space and the capacity of Reflective panels as shown in (Figure 9).

Then we press the simulation Run button in order to get the final report of the amount of energy available.

Figure 9. *shows the data entered into the program for the off-grid solar project (researcher) by PV System*

6.6 Off-Grid Sun Project Design

From the Project command, we choose Alone Stand and proceed with the same previous steps. The name of the project and its location are determined, and the direction and angle of the solar cells are selected.
From the NEED S'USER order, the numbers of electrical appliances and their capacity in the building are entered, and the consumption is defined if it is annual, quarterly or monthly. These projects are designed for areas that the electricity networks do not reach or small buildings whose devices can be calculated and then enter the data to the system as shown in (Figure 10).

sun

Figure 10. *shows the position of the Earth from the sun (Muharram Abdul Karim, 2009) PV System*

We conclude that this program facilitates the user with complex calculations, which are not without errors, and the system determines the climatic data with ease through geolocation. The system has other tasks such as designing water pumps for the solar project and entering important data to calculate the energy, which makes it easier for the user to calculate the design of the project.
From the above, the solar city can be achieved through the use of technology using PV system program, one of the solar energy simulation programs, which studies the climate of the region in order to give sound results.

7. How To Convert Solar Radiation Into Solar Energy

The sun produces a huge amount of energy because it is the center of thermonuclear processes, despite the large distance between the sun and the earth, but the amount of solar energy that reaches the earth is large. Because it is the main natural source of energy on Earth. The amount of energy received from the sun varies according to the geographical location and time, such as in different hours of the day, as well as with the different seasons of the year and the change in the inclination of solar rays with latitude and longitude, so it is possible to know and calculate the amount of energy received from the sun in a specific place and time on the relative location of the sun from the earth [16].

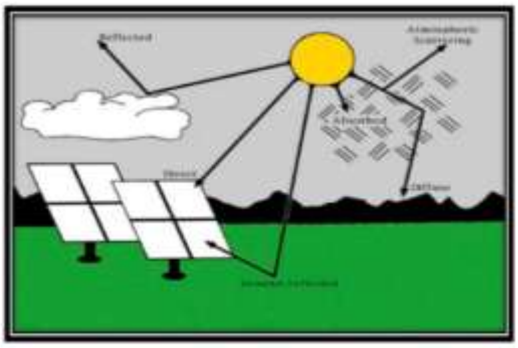


Figure 11. *shows the types of solar beams reaching the Earth (Rajput, 2017)*

7.1 Earth's Position from The Sun

From the attached figures, it is clear that the countries located on the equator go through about one season per year, during which the sun is shining throughout almost all days of the year, and the nearby countries also enjoy this characteristic where the weather is hot throughout the year. As for the countries of the north and south, they go through the four seasons according to their geographical location. As for the northern and southern poles of the earth, the sun is rare in brightness, so its solar energy is very little or even non, clouds play a role in determining the amount of sunlight that reaches the earth.
The largest amount of solar radiation reaches the earth at noon, not the radiation is perpendicular to the surface of the earth, unlike the times of sunrise and sunset, where the radiation that reaches the surface of the earth is diagonally, at noon we find that the rays in the radiation are very small, the rays are the absorption of solar radiation by clouds or

the radiation is scattered in space by airborne volcanic ash or smoke from burning forests and other environmental pollutants [17].

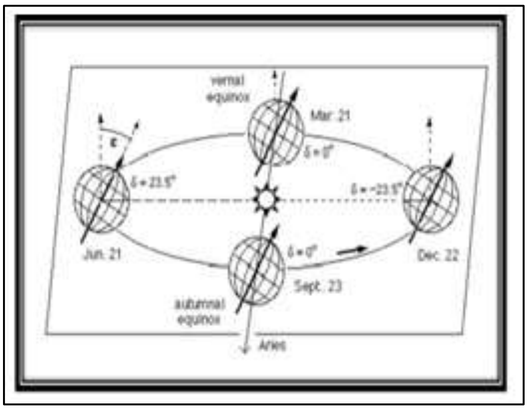


Figure 12. *indicate the earth's lust for the sun*

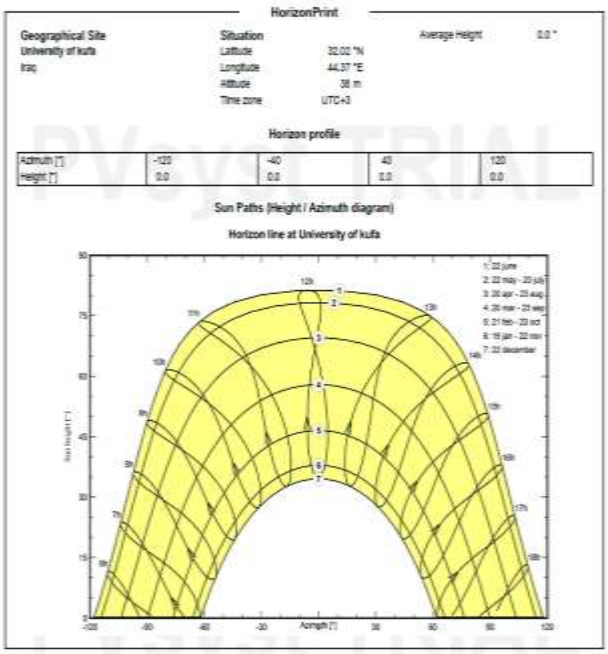


Figure 13. *showa the type of solar raditon in the study area by (pv s researcher)*

7.2 The radiation that hits the photocell is of three levels

1- Radiation Beam Direct
2- Radiation Diffuse
3- Radiation Reflected [18].

The previous figure (13) shows the small arc of solar radiation in the winter, because the day is short, while the large arc shows the solar radiation in the summer, as in:

1. June 22 is the longest day of the year and receives the largest amount of solar radiation
2. It represents the period 22 May 23 July
3. 3-It represents the period from 20 April to 23 August
4. It represents the period from March 20 to September23
5. It represents the period from February 21 to October 23
6. It represents the period from January 19 to November 22
7. 7-It represents January 22, which is the shortest day of the year

From the above chart, it appears that the highest percentage of solar radiation in the study area is in the month of June, and the lowest percentage of solar radiation is in the month of December. The purpose of addressing dust storms in the study area, because they affect the efficiency of the solar panels if they descend on them, but their impact may not be significant due to the presence ofstrong winds sometimes, which works to remove these dusts

Table 1. *Theoretical and actual brightness rates and solar radiation values in rhe city of Najaf for the period (2019-1989)*

the month	Quantity of solar radiation /cm2 /day	Theoretical brightness h/day	Actual brightness h/day
January	290.74	10.49	6.3
February	381.37	11.29	7.2
March	481.09	11.3	7.9
April	589.69	12.07	8.4
May	673.59	13.46	9.5
June	771.94	14	11.6
July	760.09	13.57	11.6
August	702.63	13.18	11.2
September	607.3	12.21	10.1
October	449.41	11.26	8.4
November	329.21	10.28	7.3
December	258.04	9.97	6.2
annual rate	524.59	10.76	8.80

(18) Source: Ministry of Ants and Communications, General Authority for Meteorology and Seismic Monitoring in Iraq, Climate Peace, data Unpublished

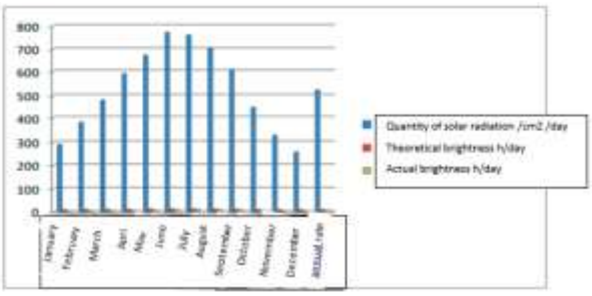


Chart (-1-) showing the sun's rays in the city of Najaf
Source: The researcher using Excel based on the table data-1-

Chart 1. *Showings the sun's rays in the city of Najaf Source: The researcher using Excel based on the table data -1.*

From the above chart, it appears that the highest percentage of solar radiation in the study area is in the month of June, and the lowest percentage of solar radiation is in the month of December [1].

8. Pearson Correlation

$$\sum_{i=1}^{n} r = \frac{n \sum X_i Y_i - \sum X_i \sum Y_i}{\sqrt{n \sum X_i^2 - (\sum X_i)^2 n \sum Y_i^2 - (\sum Y_i)^2}}$$

r=Pearson Correlation
X, y= the values of the two variables,
n= the number of the variables

In addition to dust storms, there are other climatic characteristics in the study area, such as maximum and minimum temperatures, average temperature, rainfall and humidity. By applying the Pearson correlation coefficient method, we find the relationship between the two variables, the primary variable, solar radiation, and the secondary variable, the climatic characteristics shown in the following (table.3)
The values of the Pearson correlation coefficient are limited between the two values of (+1, -1), where the positive value represents a complete positive linear relationship between the two variables and the negative value represents an inverse linear relationship between the two variables, but if the value (zero) means that there is no linear relationship between the two variables..**(20)**

Table 2. *shows the relationship between solar radiation and the number of climatic characteristics*

		degree of association	Adjective
solar radiation	Actual brightness	0.961	positive correlation (strong)
	Theoretical brightness	0.978	positive correlation (strong)
	Max temperature	0.931	positive correlation (strong)
	minimum temperature	0.932	positive correlation (strong)
	rain average temperature	- 0.898	Negative inverse correlation (strong)
	Humidity	- 0.788	Negative inverse correlation (strong)

Researcher by statistical program (spss)

Table 3. *shows the conversation of solar radiation into solar energy during the months of the year*

the month	Solar beam bulb (calorie/cm^2/day)	Constant	Amount of solar energy converted (watts)
January	290.74	0.0116	3.37
February	381.37	0.0116	4.42
March	481.09	0.0116	5.58
April	589.69	0.0116	6.84
May	673.59	0.0116	7.81
June	771.94	0.0116	8.95
July	760.09	0.0116	8.81
August	702.63	0.0116	8.15
September	607.3	0.0116	7.04
October	449.41	0.0116	5.21
November	329.21	0.0116	3.81
December	258.04	0.0116	2.9

Source / researcher based on the equation i = k * s

8.1 Converting Solar Radiation into Solar Energy

Converting the amount of solar radiation falling on the study area to solar energy is a function of knowledge about the amount of solar energy generated per unit area. The study area has high solar radiation rates of up to (771.94 calories / cm2) in the month of June, and to know that we apply the following mathematical equation:

$$I = k \times s$$

I: the amount of solar energy in watts
K: the amount of solar radiation (calories/cm^2/da)
S: constant = (0.0116) [21].

8.2 Applying The Equation, We Get the Following Data

It is evident from the above plan that the highest amount of solar energy in the study area is in June of the year and the lowest amount is in December.

Diagram (4) shows the amount of solar energy generated from solar radiation within a unit area
from the above chart that the highest amount of solar energy in the study area is in June of the year and the lowest amount is in December.

9. Study area/University of Kufa, Najaf Applied part/study area University of Kufa Educational buildings

9.1 University of Kufa's Location

The University of Kufa is located in the city of Najaf within the district of Kufa between the longitude and the latitude and height 38 m above sea level.

Map 1. *Showing the location of the University of Kufa in Najaf Governorate*

Source / GIS system /\ 32°03′028″N
44°22′022″E

The total area of the University of Kufa is (3422421.9) square meters and the map shows the location of the University of Kufa in the province of Najaf.

9.2 Designing Solar Systems at The University

The two systems were designed with a hybrid system that is, connected to the network, with storage batteries, and after entering the location data of the University of Kufa from longitude, latitude and altitude above sea level.

When the solar radiation hits the cell, the energy enters the inverter in order to convert the current from continuous to alternating and is converted into electrical energy for daily use and to supply the batteries with their needs for storage. The energy generated in this way is taken from the university's needs and the surplus is transferred to the governmental electricity networks, where it helps in supplying the neighboring areas with electric power.

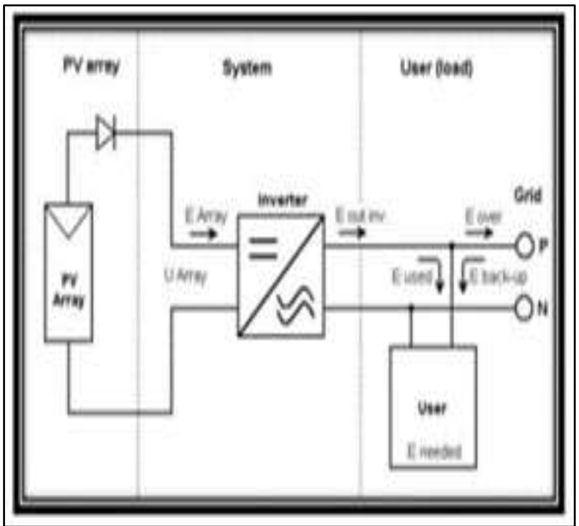


Figure 14. *shows how the solar system works by the hybrid system, source system PV*

9.3 Solar Energy For Educational Buildings

The area of the educational buildings is (137014) square meters as shown on the map in blue, and each square meter is capable of producing an estimated energy of (1500-3000) kilowatts per year. And through the design of the system for educational buildings, it was reached to:

1- Designing PV system with a capacity of (26.44) MW.
2- The number of solar cells is 66108 cells (400 LG).
3- The number of reflectors reached 1696.
4- PV system area is 122945 square meters

Map 2. *showing the educational buildings at the University of Kufa*

Source/Engineering Department at the University of Kufa

Table 5. *A comparison between the energy of solar panels and the energy that is engulfed in the electrical network generated by the solar system of university buildings throughout the months of the year*

Months	Energy of panels MMI	Energy Which injected into the grid
January	3081	3009
February	3159	3086
March	3912	3821
April	3985	3893
May	4312	4210
June	4451	4346
July	4430	4326
August	4237	4138
September	4024	3930
October	3585	3502
November	3214	3139
December	2983	2912
Total	45372	44313

source/ https://www.sisolarco.com

9.4 Converting solar energy into electrical energy in educational buildings at the University of Kufa

Map (2) also shows the current educational buildings and their location within the University of Kufa, and the panels will be installed on the roofs of the buildings.

The highest energy is produced as we explained earlier and as shown in the plan in the month of June, where the solar radiation is higher, which in turn is the main part of the work of the solar system. The.least radiation is in December, as it is one of winter months, which has the least solar radiation

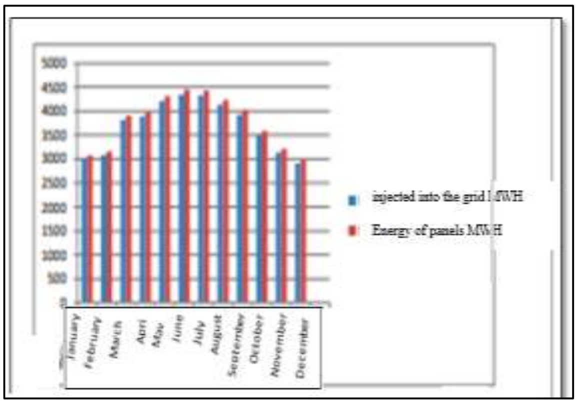


Chart 5. *Shows solar energy and electric energy generated throughout the months of the year/Source/researcher using excel*

Figure 15. *A curve showing the power and energy that supplies the electrical grid. Source: PV System Report*

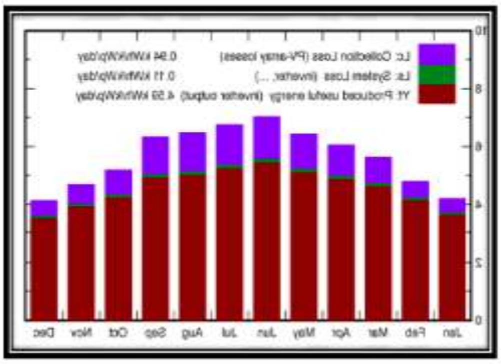


Chart 6. *Shows the annual energy production rate and the percentage of losses caused by the system and the prevailing dimitic factors in the study area (educational buildings) source/system PV*

9.5 From the previous figure, we conclude

- The blue color represents a loss of energy about (0.94 kilowatt-hours) due to a combination of environmental factors
- The green color shows a loss of (0.11 kilowatt-hours) due to the contents of the system from cells, inverters, and others.
- The red color is the useful energy produced (4.49 kilowatt-hours).
- The horizontal radiation contributed to an increase in energy production by about (14.8%), while the climatic factors affecting radiation contribute to a decrease in energy by (1.60%).
- The level of radiation contributes to an increase in energy production by (0.26%), while the temperature causes energy losses by (10.91%).
- The quality of the cells contributes to an increase in energy production by (0.75%), while the cells do not match their rows due to a loss of energy by (2.10%).
- Conduction through wires contributes to power loss by (1.09%), and the inverter and its way of working contribute to power loss by (2.26%), and the quality of the inverter has a role in power loss by (3.06%).

The diagram shows that the injected capacity to the power grid starts from (zero-18000) kilowatts, while the energy supplied to the electrical network starts From (zero-5000000) kilowatt-hours.

10. Conclusions

1. By using the Pearson method to analyze the data, we concluded that there is a direct relationship between solar radiation and actual and theoretical brightness and temperature, and an inverse relationship between solar radiation, rain and dust
2. By Pearson analysis, it was found that there is a direct relationship between the amount of energy produced and solar radiation and an inverse relationship between the amount of energy produced and rain
3. After installing and operating some solar systems in the study area, it was found that they are suitable for setting up solar projects and benefiting from the degree of solar brightness in them.
4. We were able to reduce the loss of solar energy produced, as these ceilings contribute in reducing the temperature.
5. 5-The presence of governmental electricity towers inside and near the university, it has become easy to connect solar systems with the university's electricity network.
6. The electrical energy produced from solar energy in the systems located within the university’s borders can produce enough energy for the university and its neighboring neighborhoods.
7. The economic feasibility that was developed for the project, and it was found that the solar systems are inexpensive compared to the current electrical energy.
8. After the experience of solar energy systems, it was found that the energy produced is clean and environmentally friendly, while the energy

produced from diesel generators causes noise and environmental pollution.

11. Recommendations

1. It is necessary to develop the areas of using solar energy by activating investments and evaluating the material and moral support for such projects provided by specialists.
2. Providing support and encouragement for such solar projects and cooperating with those in charge of them by the Ministry of Electricity and officials.
3. Facilitating the process of networking the system and providing them with energy in times of dust storms and rains.
4. Spreading environmental awareness by using clean renewable energies that would preserve and sustain the environment.
5. Rationalizing the use of electric energy in order to achieve sustainable development in the electric power sector.
6. Submitting indicative recommendations to the University of Kufa and the rest of the large universities to rehabilitate the solar car and return to its use to facilitate the movement of students between the university buildings that are far from each other.
7. Supporting the encouragement of the manufacture of solar systems in Iraq, in order to facilitate the provision of electrical energy necessary to sustain and improve the quality of life
8. Study the signature of solar systems in places commensurate with the prevailing climatic conditions of the site.
9. Legislating laws that preserve the environment and rationalize the use of electricity and go towards the use of environmentally friendly solar systems.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.

- **Author contributions:** The authors declare that they have equal right on this paper.

- **Funding information:** The authors declare that there is no funding to be acknowledged.

- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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