PERFORMANCE ANALYSIS OF 1 MW GRID-CONNECTED PHOTOVOLTAIC SYSTEM FOR THREE DIFFERENT ENVIRONMENTS IN SOUTHWEST BAGHDAD BY USING PV-SYSTEM SOFTWARE

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Despite the many solar energy plants that have been installed, the need to study photovoltaic systems using theoretical and practical models still exists due to the large number of variables that affect the productivity and efficiency of solar systems. In this theoretical study, a 1 MW photovoltaic (PV) system was studied in Al-Musayyb city, the Al-Razaza Lake, and Ayen Al-tamer desert in southwest Baghdad, using PVsyst V 7.4 software to choose the best location. The input data for the PVsyst are (Geographical site, power of the system, system information, and type of grid). The production of the system in Al-Musayyb city, the Al-Razaza Lake, and Ayen Al-tamer desert are 1785 MWh/year, 1885 MWh/year, and 1779 MWh/year respectively. The performance ratios for Al-Musayyb City, the Al-Razaza Lake, and Ayen Al-Tamer Desert are 0.817, 0.831, and 0.816. The current system can mitigate the emissions of CO2 for the system in Al-Musayyb city, the Al-Razaza Lake, and Ayen Al-Tamer desert to 34617 tons,32503 tons, and 32371 tons respectively through 30 years of operation. The lake environment (Floating PV system) is a better location for installing the plant than other sites due to the output energy is higher than in other environments.

Keywords: photovoltaic (PV) location, off grid-solar system, renewable energy, carbon dioxide emissions, generated energy

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1. Introduction

Due to the hard effects of using fossil fuels in our world, all countries are planning to replace the current energy sources with renewable sources. Iraq is a Middle Eastern country, that has wide plans for using renewable energy systems to avoid the bad effects of using fossil fuels. Solar PV systems are more suitable now after the huge reduction in the price of module units [1].

Although there are many solar PV systems and plants established Many researchers have studied the properties and characterizations of modified semiconductors for solar cells and photodetectors applications [2-4]. The investigation of the techno-economic-environmental outputs of solar projects before implementation is very important, especially when the design is connected with other systems and needs more complicated analysis, adjusting the design and recalculating again and again. Therefore, the simulation software for designing solar projects is very useful.

The Iraqi energy sector needs to use renewable energy to face the continued increase in the population [5]. Ibrahim et al conducted a performance analysis of a 10-MWp solar PV System in Alexandria, Egypt using the PV System simulation tool. The Photovoltaic plant was designed to do the highest performance ratio of 84 % when using p-crystalline modules and 83 % using m-crystalline modules [6]. A system 1 kWp solar PV system is designed and simulated using PV System software by Yadav et al, the performance ratio is estimated as 0.724 % by using PVsys which shows that the generation of electricity from the PV system is a viable option for Hamirpur to supplement the increasing energy needs [7]. Sharma and Chandel 2013, carried out the performance analysis of 190 kWp solar PV, the performance ratio is 74 % by using PV Sys. The average annual predicted energy yield is 823 kWh/kWp [8]. Kazem et al study the optimal configuration for a 1 MW Grid-Connected PV system in Adam City. The annual yield of the system is 1875.1 kW h/kWp [9].

A 250 kW grid-connected photovoltaic (PV) plant system has been installed since November 2017 by Ahmad et al on the Southeast Baghdad site, this study achieved the design and performance analysis using a PV System software package. The results show that the performance ratio is 75 % using 1428 photovoltaic panels type (Sharp 175 Wp) spread over an area of 1858 m². The total energy injected into the grid is (346692 kWh/year) [10].

Faizan studied a 3 MW Solar Photovoltaic Plant Using PV Syst in Pakistan, the value of the Performance ratio comes out to 83.8 %, and the total energy generation of 4908 MWh/year [11].

The design of solar energy systems must take into consideration weather and climate changes, such as dust, storms, and increasing temperatures that lead to decreased solar generation. Many Iraqi researchers have written papers on the study of these challenges [12-18]. In the field of improving the performance and efficiency of solar PV systems, there is a lot of research in this area [19-23].

In a desert environment, the high heat and dust are a challenge for reliability in PV applications. The impact of dust accumulation on photovoltaic module performance can be as much as 15 % in dry regions, and more than 20 % in desert regions [24,25]. High solar irradiation with high ambient temperature has accelerated discoloration and initiated damage to the encapsulant material [26].

The operational performance analysis of a 20 MW p-silicon photovoltaic has been achieved in a Desert Environment of Algeria. The yearly performance ratio of the system is 70.72 %, estimated between 59.13 % (in June) - 79.05 % (in January). Also, the efficiency of the system varies between 8.92 % (in June) and 11.93 % (in January) [27].

In desert and semi-arid regions, about 75 % of days had an increase in soiling on the PV panels, and the dust storms caused 8 % attenuation of solar radiation reaching the PV panels and increased the annual average soiling rate by 23 % compared to non-dust storm days [28].

Floating PV systems (FPVS) are usually installed on water bodies such as rivers, natural lakes, dam reservoirs, and marine areas. This technology has attracted attention since 2007 in several countries, such as Japan, South Korea, India, and the USA, where it has been installing many medium and large FPVSs. The floating structure could save the high cost of the land, reduction of water evaporation, evaporative cooling of PV, and tracking with optimal angles is simple and economical in designing this system [29-31]. Studies showed that installing FPVS has mitigated water loss through evaporation by ≤ 90 % [32]. Floating PV systems have lower temperatures, and higher energy generation capabilities, but, are also prone to aluminum frame corrosion of the Photovoltaic modules and other metallic components within the structures, which could be mitigated through design modifications [33]. Sujay S. and Shinde. N presented the timeline of concepts and floating solar PV projects that have been established, for research purposes or commercial use [34]. The area of water regions in Iraq is about 4,910 km^2, which equals about 1 % of Iraq's area [35], the potential of installing the FPVP on 50 % of the water reigns leads to produce about 2.2 GWh by using 300 W modules.

The present work aims to study 1 MW of off-grid PV plants under Al-Musayyb city, Al-Razaza Lake, and Ayen Al-Tamer desert climate in Iraq in order to choose the best location for installing the solar system.

2. System descriptions

The PV on-grid system used in this work is shown in Table 1.

Table 1 System configuration

Parameter	Description
No. of Inverters	40 (25 kWac)
No. of Array	91 (25 modules)
Modules Area	5062 m^2
Nominal PV power	1001 kWp

The grid does not require a storage element as the generated energy is sold back to the main grid. The PVsys v7.4.5 software database selects inverters and solar panels to satisfy the highest yearly requirements on 14/3/2024. The best tilt angle for winter sessions is 45 º at midday and 15˚ for summer, the best angle chosen forall sessions for climate Iraq is 35°. The specification of the module mono (440 W) twin 144 half-cell is listed in Table 2.

Table 2 The technical specification of Mono (440 W) twin 144 half-cell

Parameters	Value
No. of Cells	2×72 (series)
Weight (kg)	24
Dimensions (m)	1.052 x 2.115
I_{Sc} (A)	11.10
V_{OC} (V)	49.7
I_{mp} (A)	10.7
V_{mp} (V)	41.1
P_{STC} (W)	440.6
Temperature coefficient V_{OC} (mV/ºC)	-159
Temperature coefficient I_{Sc} (mA/°C)	6.3
Temperature coefficient P_{max} (%/ºC)	-0.37
Module efficiency (%)	19.8
NOCT (°C)	46
Fill Factor FF	0.799
P_{max} (W)	439.8

In current work, a complete production of the system is obtained by using a 40 (25) kWac Inverter. For Iraqi grid compatibility, the inverter output is set to 400 V (50 Hz). The specifications of the inverter are listed in Table 3.

3. Location description

3.1. Al-Musayyb city

Al-Musayyb City is an agricultural city belonging to the Babil Governorate in central Iraq. The location is 32.77 ° N latitude and 44.29 ° E longitude and the altitude is 3o m. The daily temperature in the summer varies from 35 °C to 50 °C, and in the winter is 2 °C. The Babil region is known as hot and dry in summer and cold and rainy in winter [36]. The cost of owning land in the city and agricultural land is extremely expensive, with the cost reaching millions of dollars in the city and hundreds of thousands of dollars for agricultural land, which raises the cost of establishing the project and, and reducing the economic feasibility of the project. Also, the partial shadow of trees and high buildings reduces plant production. To overcome these obstacles, it was proposed to establish the project in Al-Razaza Lake and Ayen Al-Tamer desert near the city of Karbala.

Table 3 Inverter specifications (Voltage at maximum power point)

Parameter	Value
Vmpp(60 °C)	825 V
Vmpp(20 °C)	975 V
Voc(-10 °C)	1300 V
Impp(STC)	1051 A
Isc(STC)	1110 A
Max. operating power at 1000 W/m^2 and 50°	907 kWp
Array nominal power	1000 Wp

3.2. Al-Razaza lake

Al-Razaaz Lake (32.37N, 43.67E) draws its water from the Euphrates River. It is the second-largest lake in Iraq, belonging to the Karbala Governorate. The total area is estimated at (1810) km^2, and its total storage capacity is 26 billion m^3. The rate of evaporation is about 2 to 1.5 meters per year, especially during the summer months, where evaporation is estimated at 2 cm per day.

3.3. Ayen Al-Tamer Desert

Ayen Al-Tamer (32.33, 44.29), belonging to the Karbala Governorate in central Iraq. The altitude is 50 m. The range of temperature is 5° in winter to 55° in Jun the day, and the average wind velocity is 3.5 m/s.

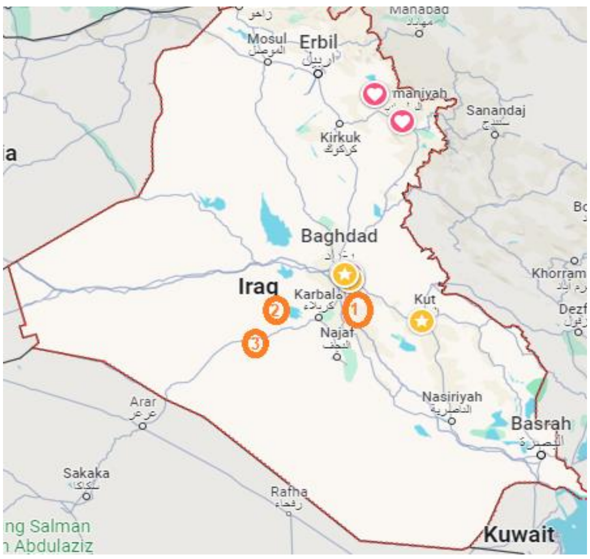

Fig 1 1 - Al-Musayyb city, 2 - Al-Razaza Lake, 3 - Ayen Al-Tamer Desert [37]

4. Result and Discussion

The temperature of Al-Musayyb city, Al-Razaza lake, and Ayen Al-Tamer desert in one year is shown in (Fig 2). Generally, the temperature degree will be lower in the winter months. According to the figure, Al-Razaza Lake has a lower temperature than both the city of Al-Musayyb and the Ayn Al-Tamer desert.

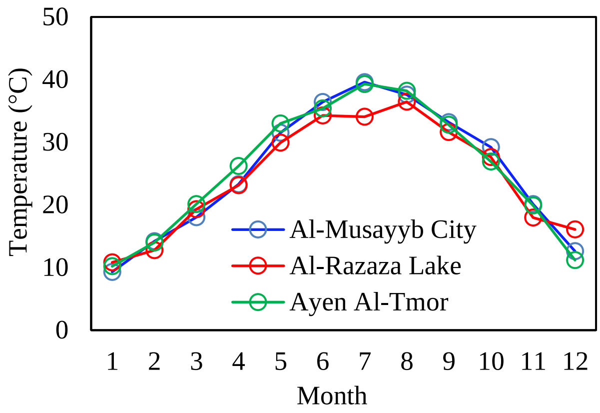

Fig 2 Temperature of three sites for one year

The value of the temperature for Al-Musayyb and Ayen Al-Tamer are irregular in winter months as a result of the effect of clouds or partially cloudy ambient.

The plant's modules' temperature is reduced and output power is increased due to this. The Al-Musayyb and Ayn Al-Tamer deserts have a high and closed temperature, resulting in lower energy production. The wind velocities of Al-Musayyb City, Al-Razaza Lake, and Ayen Al-Tamer desert are shown in Fig 3.

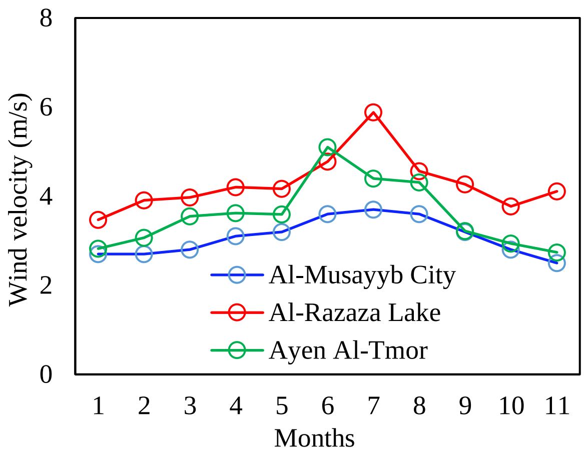

Fig 3 Wind Velocity of three sites for one year

Al Razaza Lake has a higher wind velocity than two other sites, which results in a decrease in the temperature of the modules and an increase in output power. Also, the ability to use wind energy to support the production power for the current system in Al-Razaza Lake. The wind velocity in Ayen Al-tamer is lower than in Al-Razaza Lake, but it's higher than in Al-Musayyb City.

The Relative Humidity of Al-Musayyb City, Al-Razaza Lake, and Ayen Al-Tamer desert are shown in Fig 4.

Generally, the relative humidity is higher in winter months. Figure 4 shows the amount of relative humidity for three sites, the value of it is higher in Ayen Al-Tamer than others due to not absorption and scattering by water vapor. The relative humidity is lower in al-Musayyb City and it is higher in Al-Razzaza Lake.

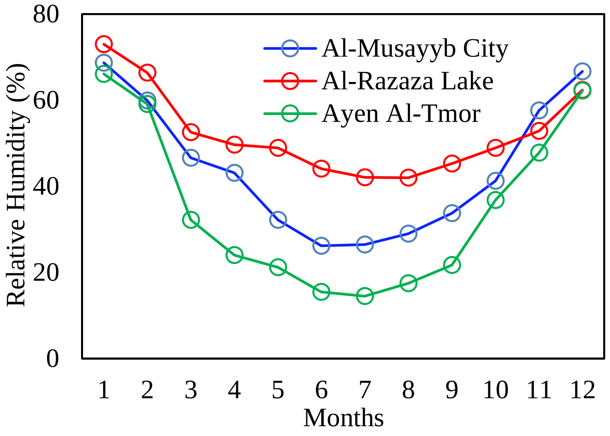

Fig 4 Relative Humidity of three sites for months (one year).

The yearly worldwide horizontal global radiation rate is 1772.8 kWh/m^2. On the collector's level the yearly efficient irradiation is 1918.6 kWh/m^2.

The daily solar irradiance incident on the tilted plane of 35° is 5.4 kWh/m^2 in Al-Musayyb city. The data of solar irradiance in Al-Musayyb city, Al-Razaza Lake, and Ayen Al-Tamer Desert are listed in (Fig 5).

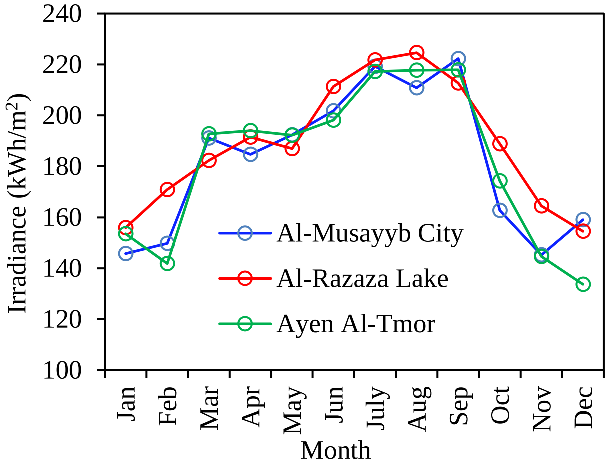

Fig 5 Global incident kWh/m^2 for three sites for months (one year).

The yearly wind speed is less, about 2.1 m\s, and the feasibility of using wind speed is not enough economy, therefor the PV system is suitable for Al-Musayyb city environment. The high temperature in summer is a challenge for using PV systems in Iraq. The Global indirect incident**,** yearly energy of Array, yearly energy Grid (injected to the grid), and percentage performance ratio (PR %) (rate of energy injected into the grid to initial energy) for Al-Musayyb city, Al-Razaza Lake and Ayen Al-Tamer desert are listed in (Fig 6).

The Global radiation incident for three sites and one year is similar due to other sites because of the three sites in the same area. In the summer months, the value of incident solar irradiance is higher.

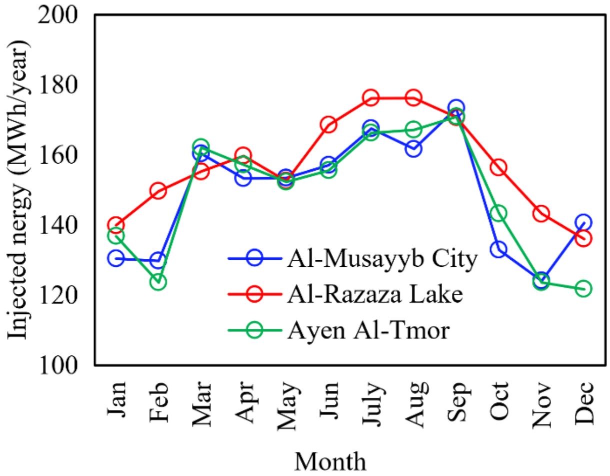

Fig 6 Injected Energy-Grid kWh/year of three sites for months (one year).

The relationship between Al-Musayyb City, Al-Razaza Lake, and Ayen Al-Tamer desert in terms of Energy-Grid MWh/year is shown in (Fig 6). Figure 6 illustrates the Injected energy-grid kWh/year injected into the National electrical grid for three sites for one year per month. Despite the high relative humidity effect, the energy grid for Al-Razaza Lake has a higher value than the other sites due to the low temperature and high wind velocity. the other two sites are similar. The yearly energy injected into the grid for three sites is listed in Table 4.

Table 4 The yearly energy injected to grid for three sites

Site	Energy (kWh)
Al-Musayyb City	1785195
Al-Razaza Lake	1884867
Ayen Al-Tamer	1778976

The relation between Al-Musayyb city, Al-Razaza lake and Ayen Al-Tamer desert performance ratio (PR) in % are shown in Fig 7.

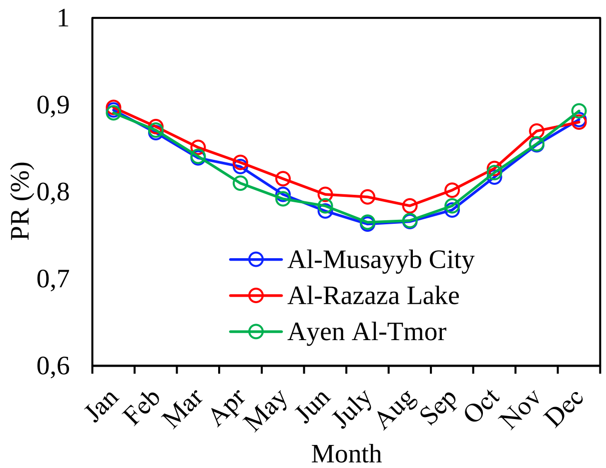

Fig 7 Performance ratio (PR) of three sites for months (one year)

Figure 7 shows the large values of the performance ratio in the winter season, and the lower value in the summer season, as a result of the effect of the high temperature on the energy gap of PV modules which produce more current, low voltages, and low output power. Figure 7 shows the plant of Al-Razaza Lake has had a higher PR value than other systems. The PR for Al-Razaza Lake is higher, as a result of the output energy injected in the national grid being higher compared with the other sites. The Al-Musayyb city and Ayen Al-Tamer are similar in PR.

The results above indicate that installing photovoltaic systems on water yields the highest productivity. However, there are some drawbacks, such as the process of installing and fixing the system in the direction of the sun, difficulty in periodic cleaning, and Algae being generated on the base of the frame. The saved CO_2 emissions for three sites with a lifetime of 30 years are listed in Table 5.

The main reasons for system loss are temperature, inverter efficiency, dust, mismatch in modules and array, irradiance level, omics wiring loss, etc.

The temperature loss is high value due to high level of temperature degrees in summer session.

Table 5 CO_2 emission savings of three sites for 30 years

Site	CO_2 saving (tonnes)
Al-Musayyb City	36648.5
Al-Razaza Lake	39165.1
Ayen Al-Tamer	37966.8

The plant needs about 10124 m^2 of lands for establishment, the price of field in Al-Musayyb city is about 150,000$ and near the electric net distribution center. The cost of 1 watt in the Iraqi market is 1$/watt, and the plant cost is 1,000,000$ which equals 148,000,000,000 Iraqi denar at price of 1\12\2023. The rate cost of produced 1 kWh of electric energy in Iraq is 0.12$. The price of one-year production of electrical energy is 198480$**.** Therefore, the amount of establishing the system will be refunded after 5.03 years without the cost of maintenance and operation.

System performance can be improved the productivity with 1D and 2D tracking, cooling the panels in summer, avoiding shade and partial shade affected, Avoid module capacity mismatch, and constant cleaning of units. The system's performance is compared with other installed PV systems for a good idea of PV solar system performance in the current study as listed in Table 6.

Table 6 Performance Ratio comparison of the PV systems installed in Baghdad.

Geographical location	System capacity (kWp)	Type of PV technology	Installation type	Energy (kWh/year)	PR (%)
North Baghdad [7]	12-grid	HIP-205NHE1	Rooftop	19530	79.2
South-east Baghdad [7]	250-grid	Sharp 175 W Mono	Carports	347000	75.0
Present study, Al-Musayyb city	1000-grid	Mono 440 W	city	1785195	81.6
Present study, Al-Razaza lake	1000-grid	Mono 440 W	lake	1884867	83.1
Present study Ayen Al-Tamer desert	1000-grid	Mono 440 W	desert	1778976	81.6
South Baghdad [9]	63-grid	REC280TP- Poly	city	111000	81.9

The value of the total energy consumed in (materials (E_m), manufacturing (E_{mf}), transport (E_t), installation (E_i), and management (E_{mg}) for each square meter of the module was proposed by Tiwari et al [38]:

$$(E_m + E_{mf} + E_t + E_i + E_{mg}) = 1516.59\ kWh/m^2 \quad (1)$$

where Total Embodied Energy (E_{em}) is the energy consumed to make the current system, which equals the (total module area * total cost of energy consumed per square meter (1516.59 *kWh/m²)* [39]:

$$(E_{em}) = Area\ modules * 1516.59\ kWh/m^2 \quad (2)$$

$$(E_{em}) = 5062\,m^2 * 1516.59\,kWh/m^2 = 7676978.58\,kWh \quad (3)$$

Emission of CO_2 due to electricity generation of the current system is 0.707 kg of CO_2 per kWh [24], the average emission of CO_2 due to the embodied energy of the PV system is:

$$(E_{em} * 0.707) = 7676978.58\,kWh * 0.707\,kg/kWh = 5427623.856\,kg \quad (3)$$

The mitigation of CO_2 emission is the quantity of CO_2 emission decrease by generating the energy from the PV system for Al Razaza lake as an example, Yearly CO_2 mitigation is [40]:

$$Eg * 0.707 = 1884867\ kWh/year * 0.707\ kg/kWh = 1332600.969\ kg/year \quad (4)$$

The CO_2 mitigation over its system life, i.e. through 30 years, the Net CO_2 mitigation for the system is [40]:

$$(Yearly\ CO_2\ Mitigation * 30year) - (CO_2\ Emissions\ due\ to\ the\ embodied\ energy)$$
$$= (1332601\ kg/year * 30\ year) - 5427624 = 34{,}550{,}405\ kg \quad (5)$$

The net CO_2 mitigation for the system in Al-Razaza is 34551.30527 tons through 30 years of operation. Also, the net CO_2 mitigation for Al-Musayyb and Ayen Al-Tamer are 32436 tons and 32305 respectively through 30 years of operation.

The widespread use of PV solar systems can be a key to solving the global warming crisis and reducing emissions of CO_2.

5. Conclusions

The use of simulation software in implementing and evaluating PV systems is very important due to the large number of variables and economic, environmental, and systems aspects associated with them. The photovoltaic system in the current study in the environment of Al-Musayyb city, Al-Razaza Lake, and Ayen Al-Tamer desert south of Baghdad showed the efficiency of production and feasibility of using the system. Al-Razaza Lake (Floating PV system) is better location for installing plants than other sites due to the output of high energy.

PV solar systems are considered valuable and should be used to provide electrical energy in the residential sector because of their net carbon dioxide mitigation.

References

1. Oleiwi, F. M., & Hameed, J. S. (2021). Renewable Energy Developments and Optical Cells as Electricity Energy in Iraq. Design Engineering, 1561-1568.
2. Chen, R., Hu, Y., Li, X., He, J., & Zhang, S. (2023). Silicon quantum dots prepared by electrochemical etching and their application in solar cells. Journal of Materials Science: Materials in Electronics, 34(13), 1105. 136002.
3. Thamri, S., & Raouadi, M. H. (2024). Enhancement of NiO/Si solar cell by adding porous silicon and a silicon dioxide SiO2 carrier selective layer. Materials Letters, 360, 136002.
4. Abed, H. R., Khudadad, A. I., & Oleiwi, F. M. (2022). Influence of the distance between nozzle and substrate on the structural, photoluminescence, and detector characteristics of p-NiO/n-Si heterojunction deposited by spray pyrolysis method. Optical and Quantum Electronics, 54(8), 482
5. KAZEM, Hussein A.; CHAICHAN, Miqdam T. Status and future prospects of renewable energy in Iraq. Renewable and Sustainable Energy Reviews, 2012, 16.8: 6007-6012.
6. Ibrahim M. Ibrahim, Ahmed S. Shehata, , Ali I. Shehata, , Mohamed A. Abbassy. (2021). Performance analysis of 10 MWp grid-conneced photovoltaic system in the Mediterranean climate using PV Syst software. International Journal of Smart Grid and Clean Energy, doi: 10.12720/sgce.10.4.286-291
7. P. Yadav. Kumar, and S.S Chandel, 2015 "Simulation and performance analysis of a 1 kWp photovoltaic system using PV Syst" International Conference on Computation of Power Energy Information and Communication (ICCPEIC).
8. Sharma, V., & Chandel, S. S. (2013). Performance analysis of a 190 kWp grid interactive solar photovoltaic power plant in India. Energy, 55, 476-485.
9. Kazem, H. A., Albadi, M. H., Al-Waeli, A. H., Al-Busaidi, A. H., & Chaichan, M. T. (2017). Techno-economic feasibility analysis of 1 MW photovoltaic grid connected system in Oman. Case Studies in Thermal Engineering, 10, 131-141.
10. Ahmed, O. A., Habeeb, W. H., Mahmood, D. Y., Jalal, K. A., & Sayed, H. K. (2019). Design and performance analysis of 250 kw grid-connected photovoltaic system in iraqi environment using PV Syst software. Indonesian Journal of Electrical Engineering and Informatics (IJEEI), 7(3), 415-421.
11. Faiz, F. U. H., Shakoor, R., Raheem, A., Umer, F., Rasheed, N., & Farhan, M. (2021). Modeling and Analysis of 3 MW Solar Photovoltaic Plant Using PV Syst at Islamia University of Bahawalpur, Pakistan. International Journal of Photoenergy, 2021.
12. Oleiwi, F. M., Kasim, N. K., & Atwan, A. F. (2021, May). PV-Solar Power Generation in Educational Institutions. In Journal of Physics: Conference Series (Vol. 1879, No. 3, p. 032070). IOP Publishing.
13. Al-Kouz, W., Al-Dahidi, S., Hammad, B., & Al-Abed, M. (2019). Modeling and analysis framework for investigating the impact of dust and temperature on PV systems' performance and optimum cleaning frequency. Applied Sciences, 9(7), 1397.
14. Shneishil, A.H., Rasheed, M.H., Dahloos, J.O. (2023). Design and mathematical simulation for the performance of 1 MWp distributed photovoltaic plant in Baghdad city. International Journal of Design & Nature and Ecodynamics, Vol. 18, No. 3, pp. 677-683. https://doi.org/10.18280/ijdne.180320
15. Enaganti, P. K., Bhattacharjee, A., Ghosh, A., Chanchangi, Y. N., Chakraborty, C., Mallick, T. K., & Goel, S. (2022). Experimental investigations for dust build-up on low-iron glass exterior and its effects on the performance of solar PV systems. Energy, 239, 122213.
16. Khan, M. U., Abbas, M., Khan, M. M., Kousar, A., Alam, M., Massoud, Y., & Jafri, S. H. M. (2021). Modeling and design of low-cost automatic self cleaning mechanism for standalone micro PV systems. Sustainable Energy Technologies and Assessments, 43, 100922.
17. Yildiz, O. F., & Yilmaz, M. (2020). Design and simulation analysis of 1 MWp grid-connected photovoltaic system at Gaziantep Airport, Turkey. Resource-Efficient Technologies, (3), 37-49.
18. Elshafei, M., Abdelrazik, S. M., & Elshenawy, A. A. (2021). Design and Simulation Analysis of 1 MWp Grid Connected Photovoltaic System Floating over Lake Nasser by using PV SYST Software.
19. Oleiwi, F. M., Hameed, J. S., & Dahloos, J. O. D. (2024). Design and Feasibility Study of A Stand-Alone Home Pv Solar System in Baghdad Climate. Iraqi Journal of Science, 160-174.
20. Kasim, N. K., Atwan, A. F., & Eliewi, F. M. 2018. Improve the performance of solar modules by reflectors . In Journal of Physics: Conference Series, 1032(1), p. 012031). IOP Publishing.
21. Kasim, N.K., Atwan, A.F., Oleiwi, F.M. and Hameed, J.S., 2019, August. Study the performance of V-Trough PV solar system with two axis tracking. In AIP Conference Proceedings (Vol. 2144, No. 1, p. 030008). AIP Publishing.

22. Kasim, N.K., Atwan, A.F. and Oleiwi, F.M., 2019. Performance of Solar Module with Presence of Two Types of Reflectors in Concentrator System. Iraqi Journal Of Computers, Communication And Control & Systems Engineering, 19(2), pp.50-57.
23. Zainulabdeen, F. S., Dahloos, J. O., Atwan, A. F., & Kasim, N. K. (2022). Optical Measurement and Performance Prediction of Solar PV System in Al-Khidhir Zone/Iraq. Karbala International Journal of Modern Science, 8(2), 1-8..
24. Havrysh, V., Kalinichenko, A., Mentel, G., Mentel, U., & Vasbieva, D. G. (2020). Husk energy supply systems for sunflower oil mills. Energies, 13(2), 361.
25. https://www.upsinverter.com/product/mono-solar-panel-400-watt/
26. Iliougine M, Carretero J, Sidrach-de-Cardona M, Montiel D, SánchezFriera P. 2008. "Comparative analysis of the dust losses in photovoltaic modules with different cover glasses". In: 23rd European photovoltaic solar energy conference and exhibition, Valencia, Spain, p. 2698–700.,
27. S. A. Alajlan,, 1999. “Photovoltaic grid-connection system as load-shaving tool in Riyadh, Saudi Arabia,” Appl. Energy, vol. 63, no. 2, pp. 91– 99,
28. Younes, M., Kahoul, N., Labed, D., Neçaibia, A., Cheghib, H., Affari, B. C., & Kherici, Z. (2023). Understanding the impact of desert stressors factors on standard PV panel performance: Case study of Algeria's desert. Scientific African, 21, e01771.
29. Benabdelkrim, B., Benattilah, A., Ghaitaoui, T., & Hammaoui, K. (2021). Experimental Analysis of a Photovoltaic Power Plant in a Desert Environment–Adrar area–. Algerian Journal of Renewable Energy and Sustainable Development, 3(1), 85-96 Javed, W., Guo, B., Figgis, B., Pomares, L. M., & Aïssa, B. (2020). Multi-year field assessment of seasonal variability of photovoltaic soiling and environmental factors in a desert environment. Solar Energy, 211, 1392-1402.
30. Javed, W., Guo, B., Figgis, B., Pomares, L. M., & Aïssa, B. (2020). Multi-year field assessment of seasonal variability of photovoltaic soiling and environmental factors in a desert environment. Solar Energy, 211, 1392-1402.
31. Rosa-Clot, M., Tina, G. M., & Nizetic, S. (2017). Floating photovoltaic plants and wastewater basins: an Australian project. Energy Procedia, 134, 664-674
32. Galdino, M. A. E., & de Almeida Olivieri, M. M. (2017). Some remarks about the deployment of floating PV systems in Brazil. J. Electr. Eng, 5(1), 10-19
33. Taboada ME, Caceres L, Graber TA, et al. Solar water heating system and photovoltaic floating cover to reduce evaporation: experimental results and modeling. Renewable Energy, 2017,105:601–615
34. Dzamesi, S. K. A., Ahiataku-Togobo, W., Yakubu, S., Acheampong, P., Kwarteng, M., Samikannu, R., & Azeave, E. (2024). Comparative performance evaluation of ground-mounted and floating solar PV systems. Energy for Sustainable Development, 80, 101421
35. Patil Desai Sujay, S., Wagh, M. M., & Shinde, N. N. (2017). A review on floating solar photovoltaic power plants. Int. J. Sci. Eng. Res, 8, 789-794.
36. https://ar.wikipedia.org/wiki/Iraq.
37. https://www.google.com/maps/place/Iraq/@33.1082697,38.4086835,6z/data=!3m1!4b1!4m6!3m5!1s0x1557823d54f54a11:0x6da561bba2061602!8m2!3d33.223191!4d43.679291!16zL20vMGQwNXE0?hl=en-US&entry=ttu..
38. https://ar.wikipedia.org/wiki/Karabala.
39. Tiwari, Arvind, Barnwal, P., Sandhu, G.S., Sodha, M.S., 2009. Energy metrics analysis of hybrid—photovoltaic (PV) modules. Appl. Energy 86, 2615–2625.
40. Khatri, R. (2016). Design and assessment of solar PV plant for girls hostel (GARGI) of MNIT University, Jaipur city: A case study. Energy Reports, 2, 89-98.