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Investigation of Some Key Factors Impacting Floating Photovoltaic Solar System Performance on Major Iraq Water Bodies

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Abstract

High population density, land exploitation, and water scarcity are the biggest problems in the world. To solve these problems, floating solar power plants were chosen because of the advantages of this system and high efficiency compared to land systems. In this study, the reservoirs of the five main dams in Iraq were chosen: Dukan, Darbandikhan, Hamrin, Haditha, and Mosul. They were covered with percentages of 5%, 10%, 25%, 50%, 75% and 100%. This study aimed to produce energy and meet the population's electricity needs and evaporation losses. The results revealed that covering the reservoirs by 100% can produce 230.53, 7526666, 15561, 244059, and 184692 MW from reservoirs of Dukan, Darbandikhan, Hemrin, Haditha, and Mosul dams respectively. Evaporation results show that covering dams by 100% can produce 14.12, 471.40, 16.34, 27.03, and 20.08 million cubic meters, the result revealed that covering the dam's reservoirs by 75% could reduce the evaporation rate by 15 times.

Keywords: Evaporation losses, Energy production in dams, Water infrastructures, Iraq dams, Floating PV system

1. INTRODUCTION

The worldwide use of renewable energy sources for meeting electricity demands is on the rise, particularly in countries where these sources are abundant. This issue is becoming more urgent due to the harmful effects of greenhouse gases on the environment resulting from the continued reliance on fossil fuels to meet global energy demands **(Stan et al., 2016; Sah et al., 2016; Pochwat et al., 2017; Stec and Zeleňáková, 2019; Kaya et al., 2021; Adebayo et al., 2021; Agyekum et al., 2021; Al-Dulaimi and Amori, 2022; Al-Dulaimi and Amori, 2023)**. Photovoltaic (PV) power systems are widely recognized as one of the most environmentally friendly energy production methods and are among the most often used worldwide **(Azmi et al., 2013; Kušnír et al., 2014; Ayeng'o et al., 2019; Sudhakar et al., 2021; Mahmood and Aljubury, 2023)**. Although PV cells are widely used for power

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generation globally, this technology still faces some problems. Therefore, scientific research must continue to advance the energy generation industry. Photovoltaic (PV) cells have an energy conversion efficiency of up to 20%, transforming the remaining energy into undesired heat. This heat increases the operating temperature of the PV panel, leading to a decline in its performance **(Majid et al., 2014; Nunes et al., 2019; Kadhim and Aljubury, 2020).** Therefore, it is essential to regulate the operating temperatures of photovoltaic (PV) systems utilizing different methodologies to obtain optimum performance. The process of PV modeling is regarded as a critical step in maximizing the extraction of power output from any given site and under various weather circumstances **(Hahsim and Abbood, 2016; Hahsim and Khaled, 2016; De La Parra et al., 2017; Silvério et al., 2018; Pasalic, Aksamovic and Avdakovic, 2018; Hasan and Farhan, 2020; Amori and Al-Damook, 2023).** In dry and semi-arid areas, improving the management of water held in reservoirs would include minimizing evaporation losses from the water surface. Nevertheless, the use of covering irrigation reservoirs remains relatively uncommon. However, with water scarcity growing more severe, a rise in demand for these systems is anticipated in the future **(Martínez-Granados et al., 2011)**. Therefore, covering the water reservoirs with floating solar photovoltaic panels (FSPVs) proposes an effective method to reduce the temperature of the PV panels and evaporation from the water surface.

Several recent studies have examined multiple factors of FSPV systems, including their overall costs, environmental effects, energy production, and efficiency in evaluating the viability of floating solar power plants. **(Choi et al., 2016)** conducted an assessment of the energy production efficiency of the FSPV (Floating Solar Photovoltaic) plant about ground-mounted systems. The results revealed that the FSPV system exhibits a 10% greater generation efficiency. **(Santafé et al., 2014)** Conducted a study on a floating solar cover for water irrigation reservoirs. The study included both practical and theoretical evaluation, employing a prototype with a capacity of 20 kWh. The investigation was conducted in the areas next to the Spanish eastern Mediterranean shoreline. The researchers determined that the FSPV system has the potential to enhance the water and energy equilibrium in regions with scarce water supplies, particularly in arid and semi-arid areas. **(Teixeira et al., 2015)** Conducted a study to determine the feasibility of implementing a floating photovoltaic (PV) system at a hydropower facility in southern Brazil to support water delivery. Their investigation revealed an initial cost of USD 1715.83 per kilowatt (kW) and an energy cost of USD 0.059 per kilowatt-hour (kWh). **(Hartzell, 2016)** Assessed the potential of Floating Solar Photovoltaic (FSPV) technology on water management infrastructure. A tiny pilot project was constructed on Lake Pleasant Reservoir, Arizona. The findings indicated that hydroelectric reservoirs have the potential to serve as optimal sites for the implementation of floating PV systems within the framework of sustainable development. **(Song and Choi, 2016)** evaluated the feasibility of installing FSPV systems on Korean mine pit lakes by conducting solar site evaluations, designing photovoltaic systems, and simulating these systems using economic and greenhouse gas emission criteria. **(Durković and Đurišić, 2017)** Did research on a sizable Floating Photovoltaic Power Plant (FSPV) in Montenegro, using an inventive azimuth angle management technique. The analysis yielded favorable results in terms of both economic savings and a substantial decrease in CO_2 emissions at the suggested power plant. **(Choi et al., 2016)** explored the feasibility of using Floating Solar Photovoltaic (FSPV) systems on 3401 reservoirs in Korea. The analysis revealed an annual power output of 2932 gigawatt-hours (GWh). Furthermore, the yearly decrease in greenhouse gas (GHG) emissions was anticipated to be 1,294,450 tons. **(Liu et al., 2017)** analyzed the power production efficiency of the FSPV plant by studying the impact of temperature changes and cooling effects via the use of a finite element model. The findings revealed a capacity of 160 gigawatts (GW) by using floating photovoltaic (PV) systems that span over 2500 (km^2) of sea surface in China. It was found that the water savings reached 2×10^{27} m^3/year water saving from evaporation and 1.25×10^{12} m^3/year indirect water saving if water saved from evaporation is being used by a hydropower plant. **(Abid et al., 2018)** carried out a comprehensive evaluation to determine the capabilities and underscore the importance of floating solar panel technology. The researchers examined several applications of FPVSs in various countries worldwide and highlighted their significance in regions with few water resources. **(Abd-Elhamid et al., 2021)** Conducted a field study on the influence of using Floating Photovoltaics (FPVs) as a protective layer on Nasser Lake in Egypt to mitigate evaporation losses. The results showed that covering 25%, 50%, 75%, and 100% of the lake surface leads to a conservation of roughly 2.1, 4.2, 3.7, and 84 billion cubic meters per year, respectively.

Reviewing the literature reveals that no work focuses on assessing FSPV application in Iraq, and therefore, the present study can pave the way for further studies.

This study offers a practical approach for evaluating many aspects of FSPV system use while considering their unique characteristics. The strategy is applied to the water infrastructure of Iraq. The five major dams in Iraq that symbolize the water infrastructure in the five major basins of the nation are the subject of the study. Taking into account different coverage situations, the study investigates the viability of putting FSPV (Floating Solar Photovoltaic) plants in these dams. The study evaluates the possibility of producing electricity and conserving water by lowering evaporation, which lowers CO_2 emissions.

The majority of FPV research has focused on different system architecture storage possibilities (**Rajbaran et al., 2019**)

1-Sland arrangements of small units, frequently placed atop a floating platform.

2-Submerged photovoltaic (PV) modules, pontoon included or not.

2. STUDY AREA

The current study evaluates the power generation and evaporation losses from five main dam reservoirs in Iraq. According to information from the Iraqi Ministry of Water Resources about the main dams in Iraq **(Hassan et aI., 2008)**, the five main reservoirs chosen for the study are the Dukan Dam, Darbandikhan Dam, Hemrin Dam, Haditha Dam, and Mosul dam. **Fig. 1** depicts the geographical locations of the five chosen dams. Solar radiation levels vary throughout various regions of the planet, with the maximum intensity seen in the solar belt of the Earth. Iraq is situated in regions characterized by elevated radiation levels. Research indicates that the use of solar equipment in Iraq is suitable and may contribute to fulfilling a portion of the country's energy requirements. With almost two-thirds of the nation seeing 310 bright days and an average radiation of 4.7~5.8 kWh/m^2.day, Iraq is recognized as a country with significant potential in the area of solar energy. Iraq has been partitioned into six regions according to the sun's radiation capacity. A brief description of each dam is presented in the following:

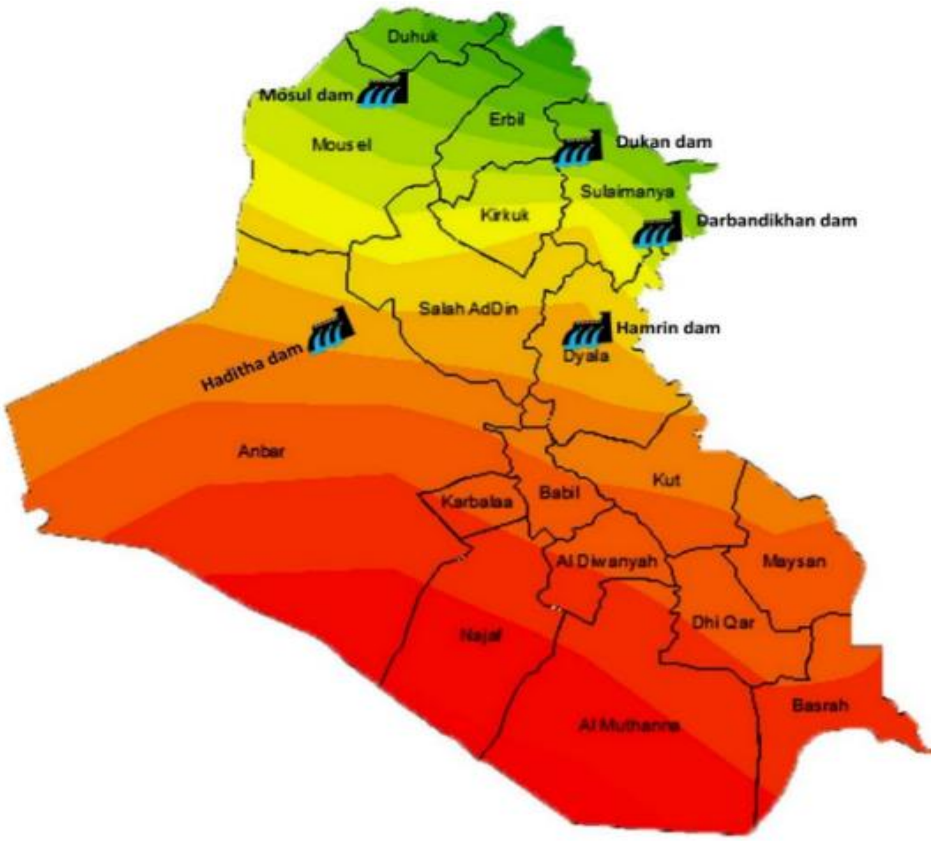

Figure 1. Map of potential solar radiation in the zones of main reservoirs of Iraq **(Aziz et al., 2023).**

Dukan Dam is located 60 km northwest of Sulaymaniyah, about 300 km from Baghdad. It is an arched concrete dam (arc radius 210). The dam's height is 116.5 m with an operational level of 511 m above sea level, the storage volume is 6.8 billion m^3, the storage area is 270 km^2, and the dam's live storage is 6.10 billion m^3. It established an electric power generation station with a capacity of 400 megawatts.

Darbandikhan Dam is located on the Diyala River near Darbandikhan District in Sulaymaniyah Governorate, 285 km northeast of Baghdad. It is the first aggregate rock dam established in Iraq to store water for irrigation, ward off the dangers of floods, and generate hydroelectric power. It is considered one of the highest aggregate dams in the world. The surface area of the reservoir is 114 km^2, with a level of 485 m above sea level. The storage capacity would be 3 billion m^3, covering a surface area of 114 km^2, estimating the amount of water that could be released for irrigation purposes (2.5 billion cubic meters between the levels of 485 m and 434 m). It also established a hydroelectric station in the dam, the number of units of which is 3, the capacity of each unit is 80 megawatts, and its design capacity is 40 megawatts.

Hemrin dam located on the Diyala River, about 100 kilometers northeast of Baghdad, Iraq. The main purpose of the dam is flood control, irrigation, and hydroelectric generation. Hamrin Dam is a pile dam with a clay core and a gravel shell, with a height of 40 meters, a length of 3360 meters at the top, a width of 8 meters, and a level of 109.5 above sea level. The highest level at the front of the dam in flood is 107.5 m, with a storage volume of 3.56

billion m^3 and a storage surface area of 450 km^2. The total storage volume of the dam is 2.06 billion m^3, at a level of 104 m above sea level. The area of the storage reservoir is 340 km^2. The hydroelectric station of the dam consists of two units with a capacity of 25 megawatts each unit .

Haditha dam located 7 km in front of the town of Haditha. Its height is 57 m, and its length at the summit is 8932 m, while the width of its base is 286 m, the width of the top of the dam is 20 m, and its level is 154 m above sea level. The operational level of the dam is 147 m, where the storage volume is 82 billion m^3 and the reservoir area is 500 km^2. The highest level of the flood is 15,002 m, which is the emergency level, with a storage volume of 10 billion m^3. The hydroelectric station consists of one generating unit Kaplan type, and the design capacity of the station is 660 megawatts .

Mosul dam located on the Tigris River, 40 km north of Mosul city. The type of dam is an orthogenic dam with a clay middle. The length of the dam's crest is 3650 m, the width of the crest is 10 m, and its level is 341 m above sea level. The operational level of the dam is 330 m, with a storage volume of 11.11 billion m^3 and an area of 380 km^2, while the highest flood level in the dam is 338.5 m, with a volume of 14.53 billion m^3, with a storage level of 330 m above sea level. The active storage capacity is 8.16 billion m^3 at the normal storage level of 330 m above sea level. The dam's power station has four units with a total capacity of 772 megawatts. The details of each dam reservoir are presented in **Table 1**.

Table 1. Details of the reservoirs.

Reservoir	City	Latitude (N)	Longitude (E)	Surface area (km^2)	Elevation (m)
Dukan	Al-Sulaymaniyah	35°57′15″	44°57′10″	270	515
Hemrin	Diyala	34°06′52″	44°58′04″	340	109.5
Haditha	Al-Anbar	34°12′25″	42°21'18″	500	154
Mosul	Nineveh	36°37′48″	42°49′23″	450	104
Darbandikhan	Al-Sulaymaniyah	35°06′46″	45°42′23″	114	485

3. ENERGY MODEL

The FSPV's hourly energy generation (W) can be estimated as follows **(Durković and Đurišić, 2017)**:

$$CapW = IA\eta \quad (1)$$

Where:

I: mean hourly insolation (W/m^2), A: surface area covered by the floating panels (m^2), and η is the efficiency of the panel and is calculated as:

$$\eta = \eta_{module}\eta_{temp}\eta_{inverter} \quad (2)$$

Where

η_{module}: efficiency degree of a module, $\eta_{invertor}$: inverter efficiency and η_{temp} is the PV conversion efficiency and is calculated as:

$$Sub\,\eta_{temp} = \eta_{STC}\left[1 - 0.0047\left(T_{panel} - 25^{o}\right)\right] \quad (3)$$

Where η_{stc} is the efficiency of PV when it is used under standard conditions (STC). The temperature coefficient of power of a photovoltaic (PV) panel is 0.0047 and The temperature of the PV panel, denoted as T_{panel}, is computed using the following formula:

$$\mathrm{Cap}T_{panel} = T_{amb} + \left(\frac{NOCT-20}{0.8}\right) I \quad (4)$$

The operating cell temperature, denoted as NOCT, is set at 44° for the chosen PV panel in this investigation and T_{amb} is the assumed ambient air temperature that was considered to be equivalent to the temperature of the dam's lake area. The chosen panel, TALLMAX, is a Chinese producer of photovoltaic modules that also works in the United States and Europe. In 2018, this firm achieved the distinction of being the first supplier of photovoltaic (PV) modules to have a total installed capacity of 3.66 GW. The PV is of multi-crystalline solar cells. The technical data of the PV and the adopted parameters are listed in **Table 2.**

Table 2. Technical data and adopted parameters **(Fereshtehpour et al., 2021)**.

Parameter	**Value**
Panel area	(1.96*0.992) m^2
Panel weight	22.5 kg
Maximum open circuit voltage	45.5 V
Maximum short circuit current	9.15 A
Peak power	320W
η_{module}	16.01%
$\eta_{invertor}$	0.96
η_{stc}	16.5%

The Energy model has been solved using Excel software based on the following assumptions:

- The temperature is uniform on the whole water surface which is assumed equal to the ambient temperature.
- The temperature of the panel is uniform.
- Number of hours the panel is exposed to the sun.

4. EVAPORATION MODEL

The FSPV plant not only prevents evaporation inside its covered area but also throughout the whole surface of the lake. Water evaporation is reduced for two primary reasons. One explanation is that when an area is covered, there is less contact between water and air, which immediately leads to a decrease in evaporation. The second reason is the alteration in the thermal equilibrium of the lake after the construction of the power plant, resulting in a decrease in the lake's temperature and thus reducing the overall evaporation throughout its whole surface. **(Durković and Đurišić, 2017)**. Accurately estimating evaporation is crucial. Several factors significantly impact the estimation of water evaporation, including the air's saturation deficit above the surface, wind speed, solar energy reaching the water surface, air pressure, and the chemical properties of water. The literature has examined the evaporation rate on water surfaces using various models. Evaporation is often measured using methods such as water budget analysis, mass transfer calculations, pan evaporation measurements, the Penman-Monteith model, and the energy balance approach. In addition, a great number of empirical relations and equations have been created that include temperature, solar day hours, and solar radiation. Penman's technique is a widely used mathematical approach that has undergone several modifications **(Penman, 1948)**. **(Valiantzas, 2006)** presented a simplified definition of this equation using regular meteorological data:

$$CapE_o = 0.051(1-\alpha)R_s\sqrt{T+9.5} - 2.4(\frac{R_s}{R_A})^2 + 0.052(T+20)\left(1-\frac{RH}{100}\right)(a_u - 0.38 + 0.54u) \quad (5)$$

where E_o is the average daily water surface evaporation (mm/day) at the sea level (z = 0), and R_s is the average sunny hours per day, calculated as follows:

$$R_s = R_A\left(0.5 + 0.25\frac{n}{N}\right) \quad (6)$$

n and N represent the average number of sunny days observed and the maximum number of sunny days possible for the chosen month, respectively. Having geographic width Φ, for a selected month (i), N can be calculated as follows:

$$N = 4\ \phi\ sin(0.53i - 1.65) \quad (7)$$

$$R_A = 3Nsin(0.131N - 0.95\phi) \qquad |\phi| > \frac{23.5\pi}{180} \quad (8)$$

$$R_A = 118\ N^{0.2}sin(0.131N - 0.2\phi) \qquad |\phi| > \frac{23.5\pi}{180} \quad (9)$$

α represents the reflection coefficient, which is also known as albedo. It depends on the water surface and ranges between 0 and 1. It is taken as 0.08 in the present study. T is the average of extreme temperatures ($T_{\min}$, T_{max}) for the analyzed month (°C):

$$T = \frac{T_{max}+T_{min}}{2} \quad (10)$$

The daily average relative air humidity is denoted as RH, and u is the mean wind speed (in meters per second) at a height of 2 meters above the lake surface. Equation 5 is adjusted empirically for higher altitudes z (m) **(Valiantzas, 2006)**:

$$E = E_o + 0.00012\ z \quad (11)$$

The daily volume of water evaporated can be determined by multiplying the amount of evaporation (E) by area of the lake (A):

$$V(m^3/day) = E(m/day)\ A_{Lake}(m^2) \quad (12)$$

5. RESULTS

5.1 Meteorological Data

Fig. 2 displays the monthly average weather conditions to provide a clearer representation of the variations in the circumstances of the dams under investigation. Haditha Dam has the highest maximum temperature among the studied dams, while Darbandikhan has the lowest. Regardless of the temperature of the last months of the year, it can be said that the

Hidatha dam has the highest minimum temperature among the studied dams. In contrast, the Dukan Dam has the lowest minimum temperature This is because Darbandikhan and Dukan Dams are situated in the mountainous regions of the northern region of Iraq, which are of a lower temperature than the region in which Haditha Dam is situated in the eastern region of Iraq, which is characterized by a higher average temperature. The wind velocity in the area of Hemrin Dam has the highest value during July, August, and October, while the Darbandikhan Dam area has the highest wind velocity after October to the end of the year. The area of Haditha Dam has the lowest wind velocity during the studied period. This is because the Hemrin and Darabandikhan dams are in the mountain terrains in the north of Iraq. The relative humidity for areas of all dams during July, August, and October are nearly the same. At the end of the year, the Hemrin zone has the highest relative humidity while the Haditha area has the lowest relative humidity.

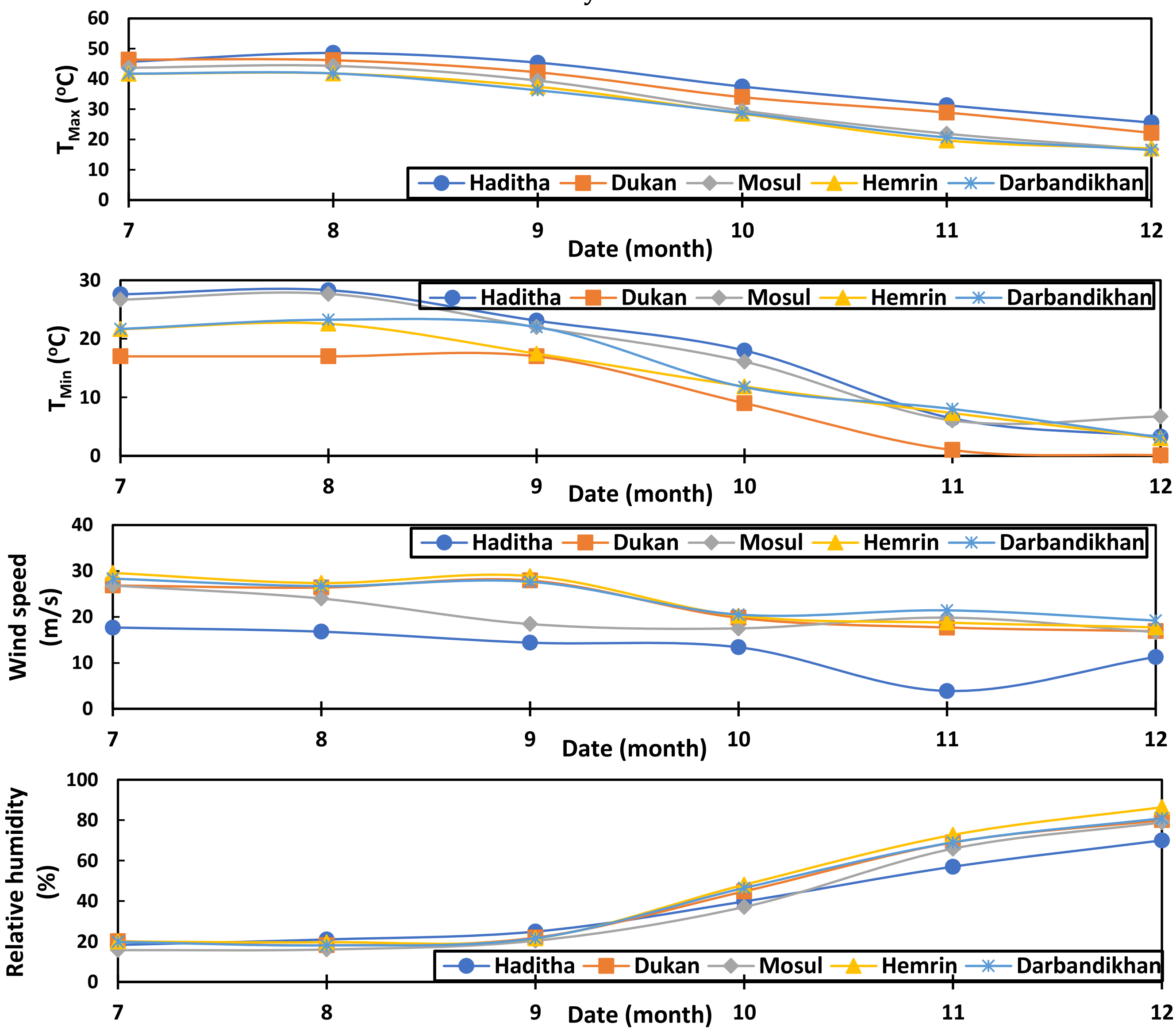

Figure 2. Weather data for locations of the studied dams (**Hassan et al., 2008**).

5.2 Energy Production

The annual energy production from Dukan, Darbandikhan, Hemrin, Haditha, and Mosul dam reservoirs are shown in **Figs. 3 to 7** respectively for different coverage ratios of 2%, 5%, 10%, 25%, 50%, 75% and 100% during the period from July to the end of December. In General, energy production increases with the increase of solar radiation due to the increased input energy to the solar panel. Also, increasing the coverage percentage results in higher energy production due to the increased number of PVs and reduced water temperature. The highest energy production is in Darbandikhan dam due to the large surface area that requires a larger number of solar panels. A ratio of 2% is sufficient to meet the governorate's need, which is estimated at 15053 megawatts. Coverage ratios of 2% and 5% are considered the bast and sufficient ratios to meet the governorate's need for electrical energy

Table 3 summarizes the energy production for the all-dams reservoirs for coverage percentages of 5%, 10%, 25%, 50%, 75% and 100%. Darbandikhan reservoir has the highest energy production while Dukan has the lowest energy production. This is because Darbandikhan zone has the lowest monthly average maximum temperature between the investigated dams which result in lower PVs working temperature which in turn increases the efficiency of the PV panel. Also, Darbandikhan zone has the highest wind velocity which leads to a better heat exchange between the surrounding air and the PV panel that result in reduction in the PV panel temperature. The temperature is at its highest value in August ,while it begins to drop to a minimum value in the December. The wind speed highest value in October. This is due to the influence of the degree of humidity in this month, where the humidity level is lowest in October, and this is the reason for an increase in the speed. the wind that the humidity is low. The variation between the energy production of each reservoir surrounding temperature, wind velocity, relative humidity, and solar radiation.

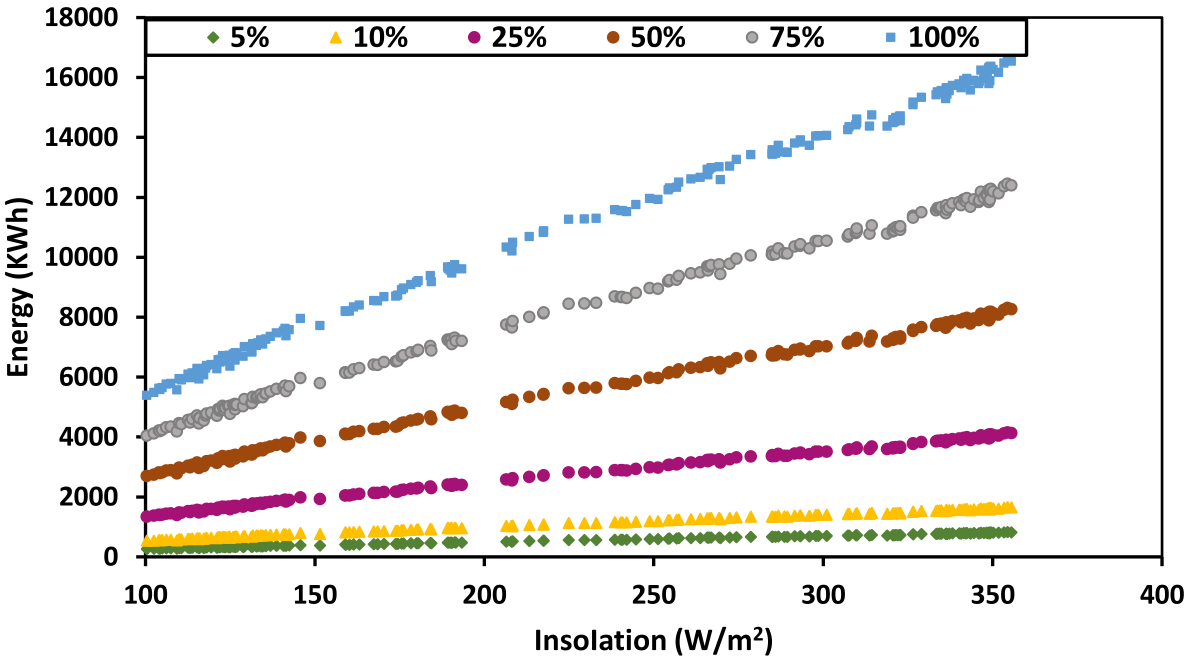

Figure 3. Annual energy production of solar panel array with the corresponding coverage percentage area of Dukan dam.

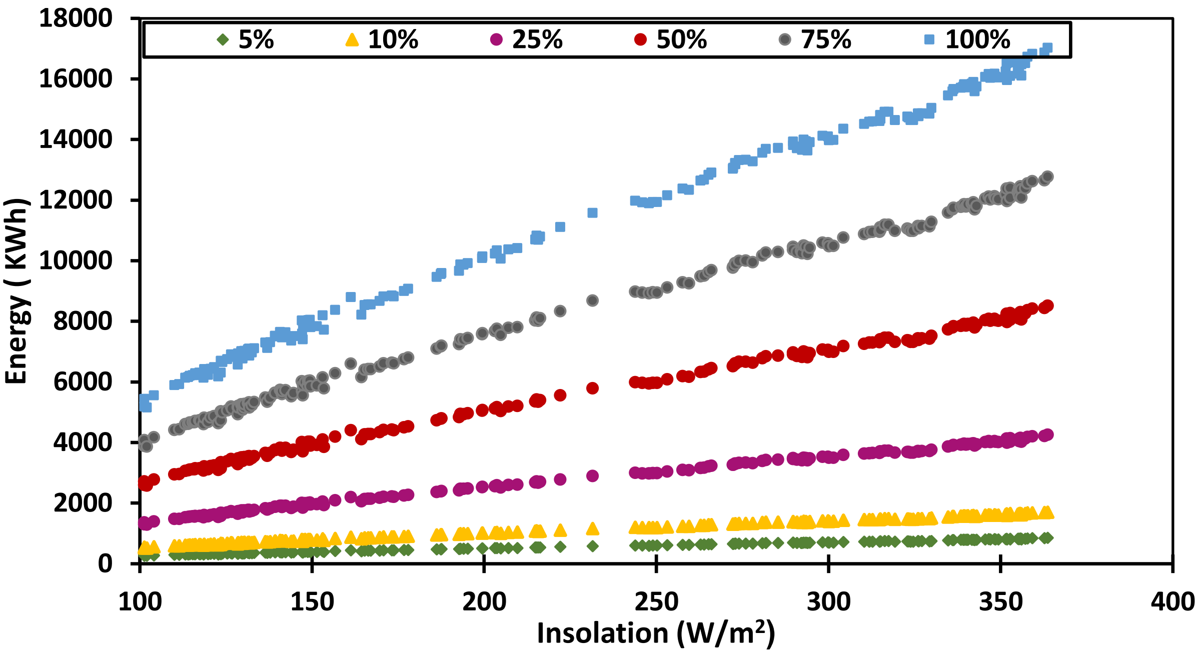

Figure 4. Annual energy production of solar panel array with the corresponding coverage percentage area of Darbandikhan dam.

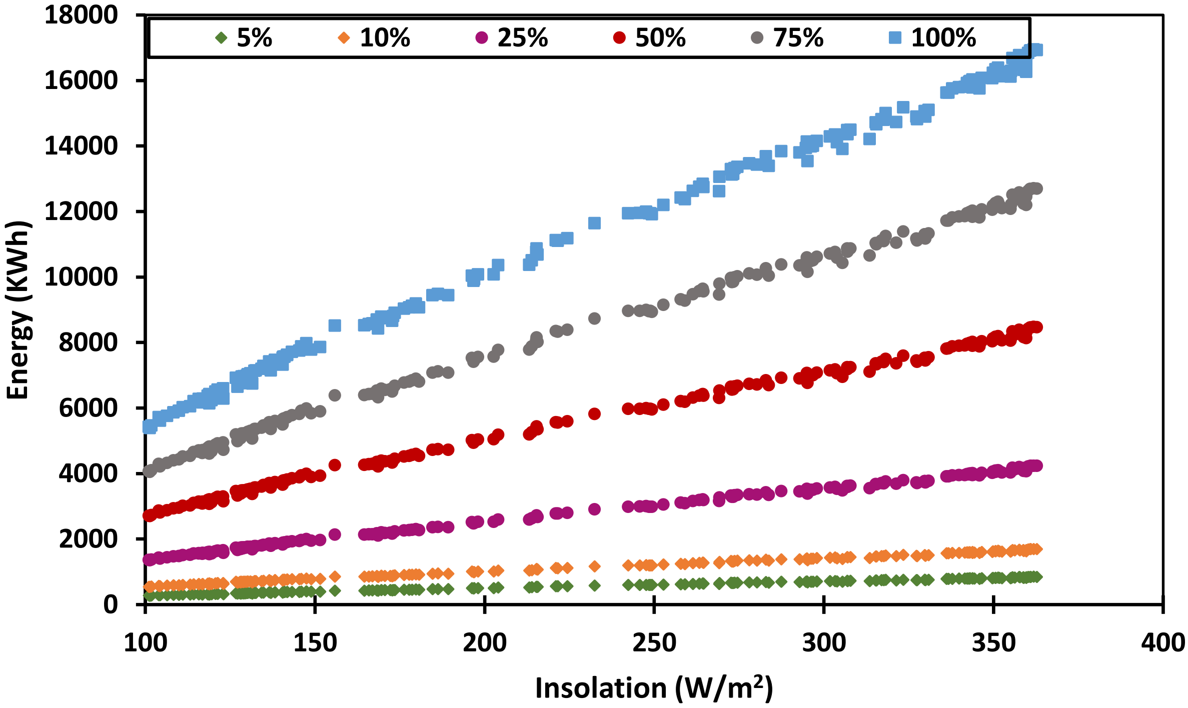

Figure 5. Annual energy production of solar panel array with the corresponding coverage percentage area of Hemrin dam.

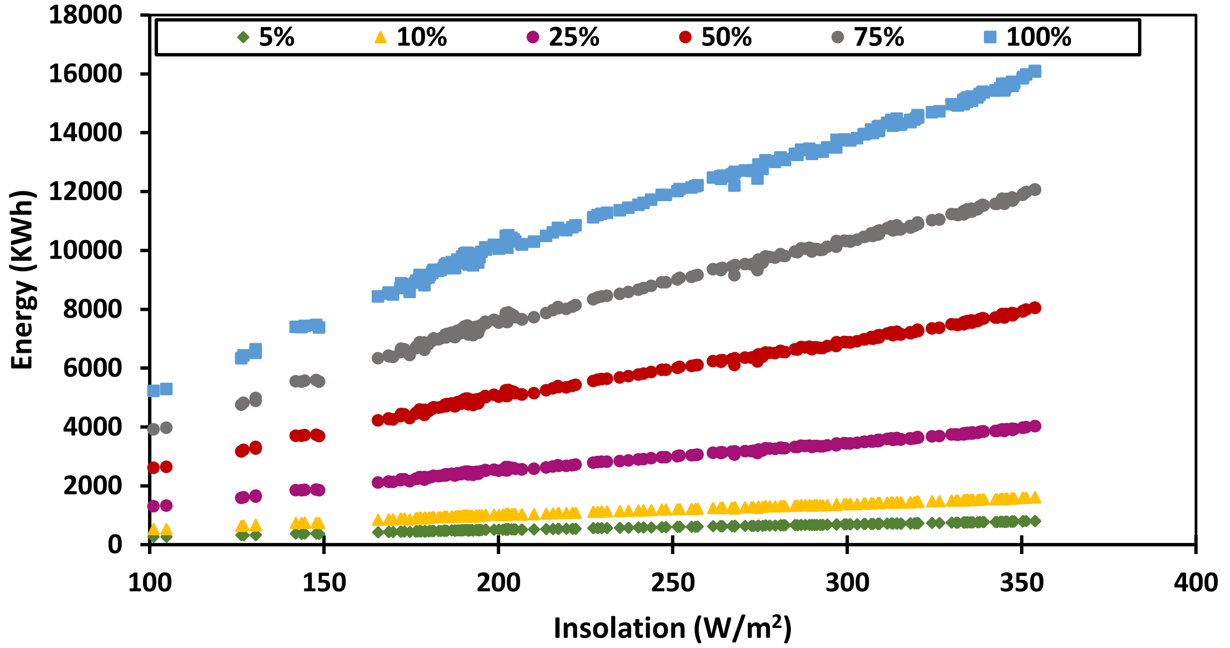

Figure 6. Annual energy production of solar panel array with the corresponding coverage percentage area of Haditha dam.

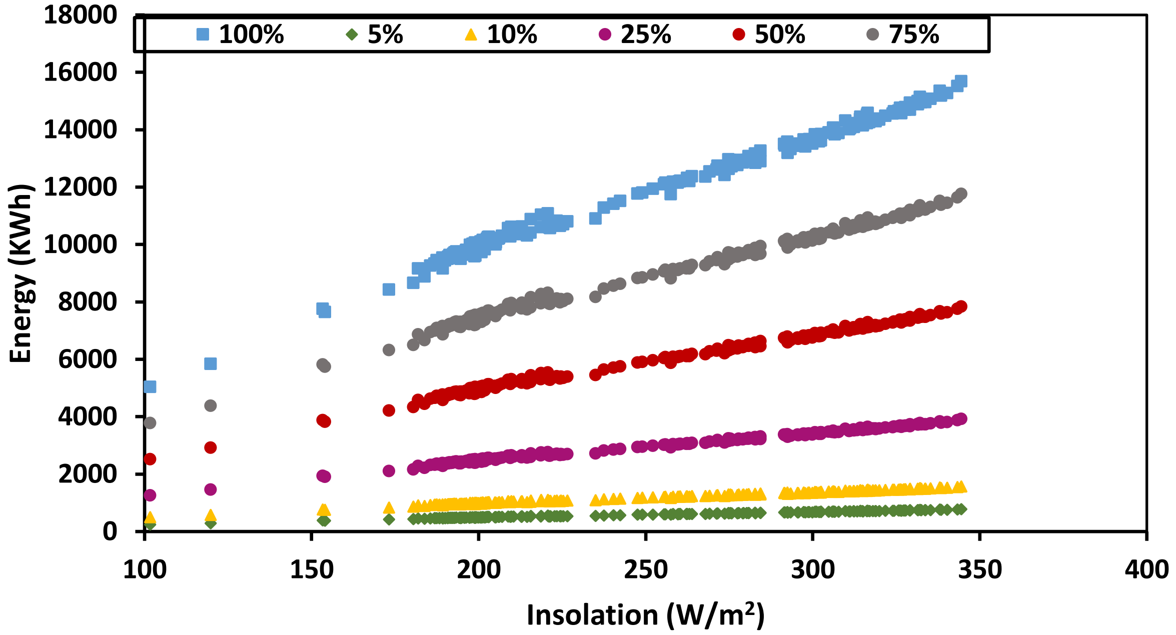

Figure 7. Annual energy production of solar panel array with the corresponding coverage percentage area of Haditha dam.

Table 3. Output power generated by each dam reservoir

Type of energy	Dam	FSPV Coverage percentages					
		5%	10%	25%	50%	75%	100%
Energy generated (10^6 Wh)	Dukan	11.5	23.05	57.63	115.26	172.90	230.53
	Darbandikhan	37633	75266	188166	376333	564500	7526666
	Hamrin	778	1556	3890	7780	11671	15561
	Haditha	12262	24405	61014	122029	183044	244059
	Mosul	9234.6	18649	46173	92346	138519	184692

5.3 Evaporation Rate

There are several ways to reduce evaporation, but in the current study covering the reservoir's water surface partially is the best way to reduce evaporation taking into account the thermal balance due to the reflection of part solar energy.

Fig. 8 presents the effect of water temperature on the evaporation rate from the water surface of the different dam reservoirs. Increasing the water temperature increases the evaporation rate because water molecules exhibit more molecular motion and possess greater kinetic energy at higher temperatures. The higher energy facilitates the ability of some molecules to overcome the cohesive forces that bind them to the liquid, allowing them to transition into the atmosphere as vapor via the process of evaporation.

Table 4 lists the evaporation reduction rate for each dam reservoir at different coverage percentages. It can be seen for the higher coverage percentage; the evaporation decreases at a higher rate. This is due to the reduced water temperature due to the shading and the lower contact area between the water surface area and the surrounding air.

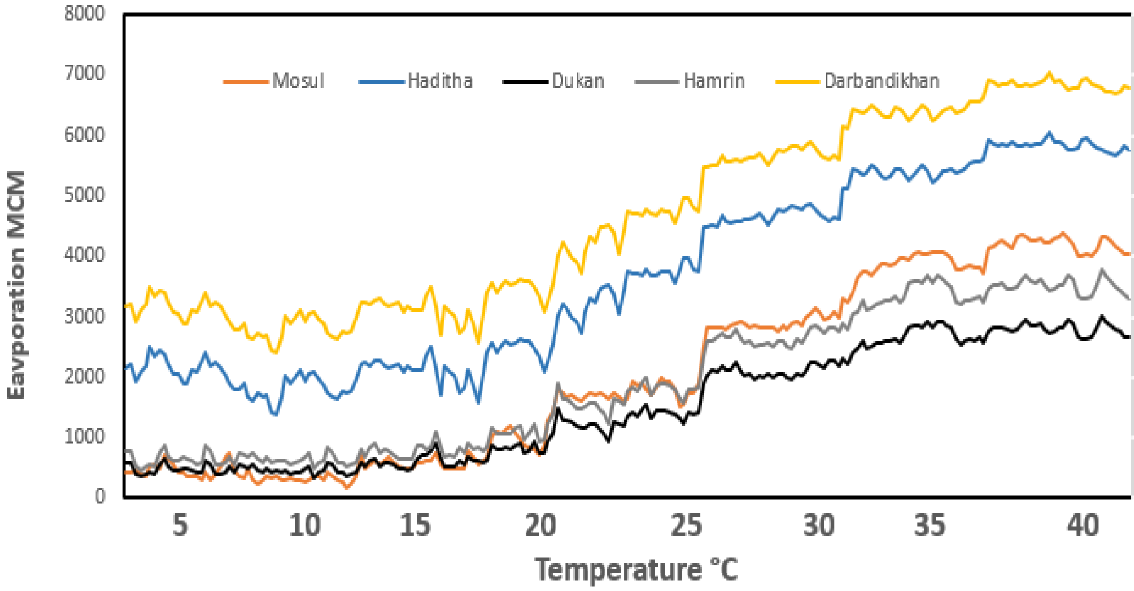

Figure 8. Effect of temperature on the evaporation rate (**Hassan et al., 2008**)

Table 4. Evaporation rate reduction (MCM) with the corresponding coverage percentage area **(Fereshtehpour et al., 2021)**

Dam	**5%**	**10%**	**25%**	**50%**	**75%**	**100%**
Dukan	0.706	1.412	3.53	7.06	10.59	14.12
Darbandikhan	2.3	4.7	11.8	23.5	35.3	47.3
Hamrin	0.817	1.634	4.085	8.17	12.25	16.34
Haditha	1.351	2.703	6.757	13.51	20.27	27.03
Mosul	1.04	2.08	5.2	10.4	15.6	20.80

6. CONCLUSIONS

One of the most important sources of renewable energy is photovoltaic energy. However, due to the radiation falling on water, a large amount evaporates. This led to the work of a new energy technology called floating photovoltaic energy. Its advantages include protecting water reservoirs and resources against evaporation and the production of electrical energy from the sun. A comprehensive review of the literature on the application of FSPV is conducted. Five dams are selected for this study: Dukan, Darbandikhan, Hemrin, Haditha, and Mosul. the results of this research can be found from: -

- Covering the reservoirs of five dams provides very high energy, for 5% coverage percentage the energy production of Dukan, Darbandikhan, Hamrin, Haditha, Mosul dams is 11.5 MW,37633 MW, 778 MW, 12262 MW and 923.4 MW respectively.
- Covering water surface by 100% is almost impossible to implement in reality, due to the exploitation of the entire area of the dam.
- Increasing coverage rates from 2% to 75% leads to an increase in water savings by 15 times.
- The surface area of the dam reservoir, the temperature, the amount of incident radiation, and the degree of humidity are the most important factors that affect the amount of evaporation.

The proposed models of energy and evaporation are limited to a horizontal solar panel. As potential for future development, the proposed model can be amended to investigate the performance of inclined solar panels. A sun-tracking system can be used to enhance energy generation and the performance of the FSPV

NOMENCLATURE

Symbol	Description	Symbol	Description
A	Covered area by the floating panels, m^2.	RH	Relative humidity,%
A_{Lake}	Water surface Area, m^2	u	Wind speed, m/s
E_o	Average evaporation at sea level, mm/day	V	Volume of water evaporated, m^3/day
E	Average evaporation, mm/day	W	Hourly energy generation, Watt
I	mean hourly insolation, W/m^2.	z	Sea level, m
T_{panel}	PV panel temperature, ^{o}C	α	Albedo, 0.8
i	Month number	η	Efficiency
n	Average number of sunny days	η_{stc}	Standard efficiency
N	Maximum possible number of sunny days	η_{temp}	Conversion efficiency
R_s	Average sunny hours	η_{module}	Module efficiency
T_{amb}	Ambient temperature, ^{o}C	$\eta_{invertor}$	Standard conditions
$T_{\max}$	Maximum temperature, ^{o}C	φ	geographic width, degree
$T_{\min}$	Minimum temperature, ^{o}C		

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Credit Authorship Contribution Statement

Zeena A. Abdulhadi**:** Conducting and analyzing results and writing references. Emad T. Hashim: Visualization and his writing abstract and introduction. Moneer H. Tolephih: Discussion and linguistic review.

Declaration of Competing 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.

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دراسة العوامل التي تؤثر على أداء النظام الشمسي الكهروضوئي العائم على البنى التحتية المائية الرئيسية في العراق

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الخلاصة

كثافة السكانية عالية واستغلال الأراضي وقلة المياه تعتبر من اكثر المشاكل التي يواجها العالم. ولحل هذه المشاكل تم اختيار محطات الطاقة الشمسيه العائمة بسبب مزايا هذا النظام والكفاءة العالية مقارنة بالآنظمة الارضية. في هذه الدراسة تم اختيار خزانات السدود الخمسة الرئيسية في العراق: دوكان , دربندخان , حمرين , حديثة والموصل تم تغطيتها بنسب مختلفة 5% , 10% , 25% , 50% , 75% و 100% هدف منها انتاج الطاقة وسد احتياج السكاني من الطاقة الكهربائية وخسائر التبخر. أظهرت النتائج أن تغطية الخزانات بنسبة 100% يمكن أن تنتج 230.53، 7526666، 15561، 244059 و184692 ميغاواط من خزانات سدود دوكان ودربنديخان وحمرين وحديثة والموصل على التوالي. كما أظهرت النتائج التبخر ان تغطية خزانات السدود بنسبة 100% يمكن لن ينتج 14.12 , 471.40 , 16.34, 27.03 و 20.80 مليون متر مكعب من كميه التبخر أن بنسبة 75% يمكن أن تقلل من معدل التبخر 15 مرة.

الكلمات المفتاحية: النظام الكهروضوئي العائم، إنتاج الطاقة في السدود، البنية التحتية للمياه، السدود العراقيه، خسائر التبخر.