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Study and Analysis for High Performance of Hybridization Floating Solar Panels Technique with Hydropower

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Keywords:
High performance; Hybridization; Floating solar panels; Hydropower; Haditha dam; Hybrid electrical station.

Highlights:

- *Hybrid NN+GBDT model boosts healthcare prediction accuracy (AUC: 0.92).*
- *Combines neural networks' pattern recognition with GBDT interpretability.*
- *Outperforms standalone models (logistic regression, random forest, NN).*
- *Clinically actionable via GBDT's rule-based feature importance insights.*

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Abstract: Addressing water and energy shortages in Iraq is of critical importance. In recent years, the country has faced challenges in energy supply due to a decrease in hydroelectric station production caused by several factors, such as high temperatures, lack of rainfall, and water evaporation. Installing floating solar panels is a modern technique to mitigate low energy production and reduce water evaporation. This study examines the feasibility of implementing this technique at Haditha Dam Station in Iraq using practical data obtained from simulation environments. The results showed that it is possible to preserve the water reserve and increase the production efficiency of the station by installing floating panels. The paper discusses various aspects of floating solar panel installations, including orientation, inclination angles, supporting structures for different environments, materials used, and modeling techniques through software applications like Homer.

دراسة وتحليل الأداء العالي لتقنية تهجين الألواح الشمسية العائمة مع الطاقة الكهرومائية

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الخلاصة

إن معالجة نقص المياه والطاقة في العراق أمر بالغ الأهمية، وفي السنوات الأخيرة، واجهت البلاد تحديات في إمدادات الطاقة بسبب انخفاض إنتاج محطات الطاقة الكهرومائية بسبب عوامل مثل ارتفاع درجات الحرارة، وقلة هطول الأمطار، وتبخر المياه. إحدى التقنيات الحديثة للتخفيف من انخفاض إنتاج الطاقة وتقليل تبخر الماء هي تركيب الألواح الشمسية العائمة. تبحث هذه الدراسة في مدى جدوى تطبيق هذه التقنية في محطة سد حديثة في العراق باستخدام البيانات العملية التي تم الحصول عليها من بيئات المحاكاة. وأظهرت النتائج أن تركيب الألواح الشمسية العائمة يحافظ على مخزون السد المائي ويزيد من كفاءة الإنتاج. تناقش الورقة الجوانب المختلفة لتركيبات الألواح الشمسية العائمة، بما في ذلك الاتجاه، وزوايا الميل، والهياكل الداعمة لبيئات مختلفة، والمواد المستخدمة، وتقنيات النمذجة من خلال تطبيقات برمجية مثل هومر.

الكلمات الدالة: الأداء العالي، التهجين، الألواح الشمسية العائمة، الطاقة الكهرومائية، سد حديثة، محطة كهربائية هجينة.

1.INTRODUCTION

Growing the global population increased energy, agricultural land, and housing demand. This increase rose demand leads to the depletion of non-renewable resources, such as coal and oil, making it essential to explore renewable energy sources. Solar energy is considered one of the most abundant and limitless energy sources worldwide [1-3]. However, conventional photovoltaic (PV) systems require large areas of land, which can lead to deforestation, bird deaths, and erosion, with an average consumption of 0.5-0.7 MW/ha for ground-based PV power plants [4]. Limited space availability and high costs pose challenges for installing solar power plants in countries experiencing rapid population growth [5]. Additionally, high-temperature coefficients negatively impact PV panels' performance [6-9]. Floating Photovoltaic Solar (FPV) systems offer a new approach by installing solar panels on water bodies, benefiting from water cooling while mitigating negative thermal effects on solar modules [10]. Water may soon become a popular technique for tracking solar energy due to FPV's positive aspects [11-14]. FPV systems have introduced new possibilities for increasing solar power generation capacity, particularly in landlocked countries with limited land availability [15-20]. The primary objective behind this technology is to utilize expansive water surfaces as sites for generating power while controlling system temperatures through water cooling mechanisms (see Figure 1) [21]. Ideal locations for implementing FPV systems include non-touristic or recreational waterscapes, such as sewage treatment plants, fishponds, industrial ponds, or lakes [22-31]. Numerous large-scale projects involving FPV technology have been developed in recent years, taking advantage of diverse climatic factors such as temperature (Ta), solar radiation (G), wind speed (VW), and water temperature (WT). This diversity has increased efficiency in renewable energy systems [32-38].

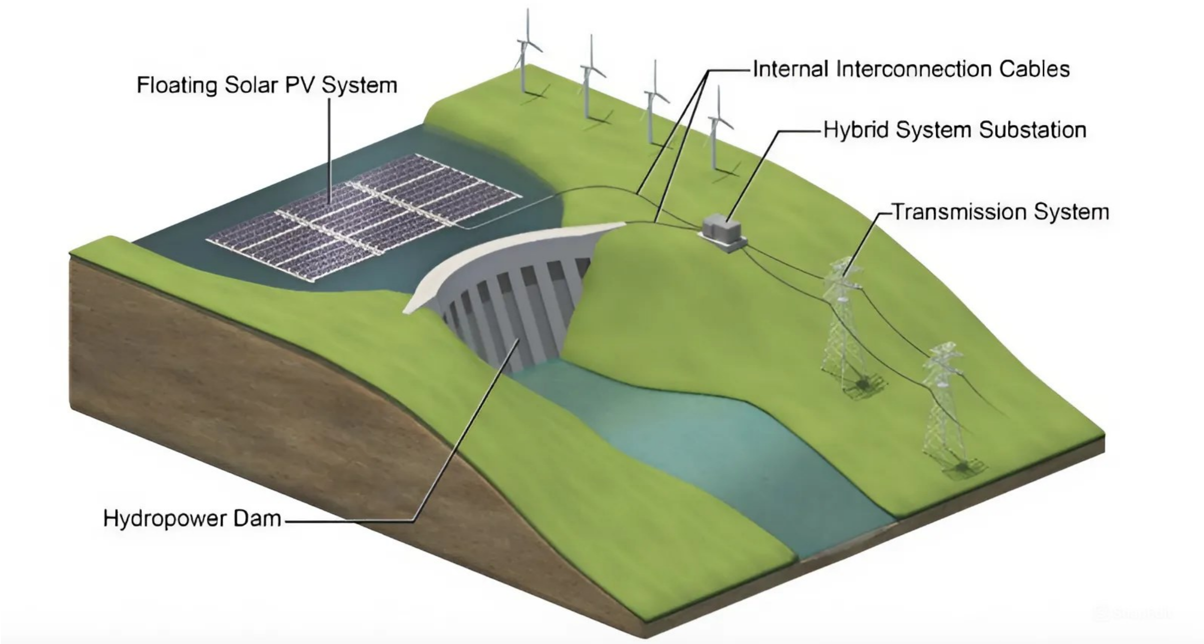

Fig. 1 The Operations of Merging Hydroelectric Power Plants and Floating Pv Generating [9].

In this research, floating platforms made from high-density polyethylene (HDPE) can be utilized to reduce water evaporation by up to 70%, leading to significant water conservation [39]. Moreover, energy generation from photovoltaic cooling systems has increased by approximately 6% [40-43].

2.CASE STUDY

The modeling of the overall hybrid power system considers actual data from one of Iraq's most prominent hydroelectric power stations, i.e., Haditha Dam Hydroelectric Station (see Fig. 2). Due to low water levels in the Euphrates River, the efficiency of this station has been reduced by 80% [44] compared to its designed capacity. As a result, introducing a Floating Solar Panel (FSP) hybridization is proposed as an additional energy source for this location [45].

Fig. 2 Haditha Hydroelectric Dam Station [44].

By harnessing solar energy available in this region, which experiences up to 14 hours of sunlight during summer and 10 hours during winter, it is possible not only to supplement electricity production but also to reduce water evaporation caused by high temperatures that could reach up to 50 °C. A hybrid plant incorporating hydro and solar sources can address challenges faced by energy exporters since hydropower compensates for unstable solar energy production with its rapidly adjustable output [46]. Simultaneously, solar energy conserves water reserves while leveraging positive aspects, such as extended daylight hours and minimal cloud coverage. Combining these technologies offers economic benefits by producing more energy from the same site while utilizing existing infrastructure components, like transformers, cranes, transmission lines, and operating teams trained on operating and maintaining floating solar systems [47]. While prices for these hybrid systems might be higher in the electricity market initially, they provide greater flexibility in managing consumer product distribution, adding versatility makes them an attractive solution for addressing modern-day renewable-energy challenges [48]. The Haditha Hydroelectric Dam Station, Iraq's second-largest hydroelectric facility, boasts 8.28 billion cubic meters of water storage capacity. Comprising six generating units with an individual capacity of 110 MW each [49]. The station has a total power generation capacity of 660 MW. The dam stands at a height of 57 m and spans 8933 m in length, while its base measures approximately 386 m wide [50]. The dam's top width is around 20 m. It operates at an elevation level of about 147 m above sea level with a vast storage area encompassing roughly 503 m². The emergency floodwater levels reach up to 150.2 m high, allowing for additional water storage amounting to almost 10 billion cubic meters spread over an expanded area measuring nearly 575 m² [51].

3.DESIGN OF A FLOATING SOLAR PANEL

A crucial aspect of solar panel installation is their orientation, which ensures maximum exposure to sunlight and the most efficient angle of incidence. The optimal direction for positioning panels depends on whether a site is north or south of the equator. In the case of Haditha Dam Lake, situated north of the equator, it is ideal to face solar panels towards the south due to the east-to-west sun trajectory that renders its circular path perpendicular to panels for extended periods.

The inclination angle of these panels varies across different seasons throughout Iraq's four distinct annual climate phases. The primary determining factor in this context is latitude, which measures approximately 41.5518226° in Haditha Dam. During autumn and spring, panel inclination matches latitude at 41.5518226°; however, adjustments are made according to seasonal changes (see Fig. 3).

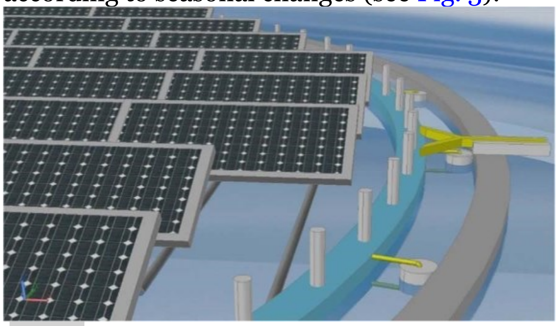

Fig. 3 Tracking Within a Confining Structure.

In summer, an inclination angle equaling latitude minus 15° (26.5518226°) maximizes solar radiation absorption capacity. Conversely, winter conditions call for an increased incline totaling latitude plus 15° (56.5518226°). These strategic alterations account for varying levels of sunlight exposure over time and ensure optimum energy production from installed solar systems.

4.CASTE RULES FOR FLOATING SOLAR PANELS

Installation guidelines for floating solar panels differ from those for ground-mounted systems due to their positioning on the water's surface.

Uneven surfaces, coupled with wind and water forces, can cause potential damage, such as cracks that may reduce the panels' lifespan. Since this technology's inception, several solutions have emerged to address these challenges, including using galvanized iron supported by polyethylene pipes [22]. As demonstrated in an aerial photo of a Rover-to-FPV setup (Fig. 4), the system underwent several tests in harsh conditions, exposed to wind speeds of 140 km/h without encountering any issues. This approach ensures enhanced durability and reliability for floating solar panel installations despite environmental stressors associated with their aquatic settings [23].

Fig. 4 PVF plant Tracking in Suvereto (Italy) [23].

A project for floating panels was established in Korea, as shown in Fig. 5, in 2012. It is a practical example of implementing innovative floating solar panel technology for harnessing renewable energy resources [24].

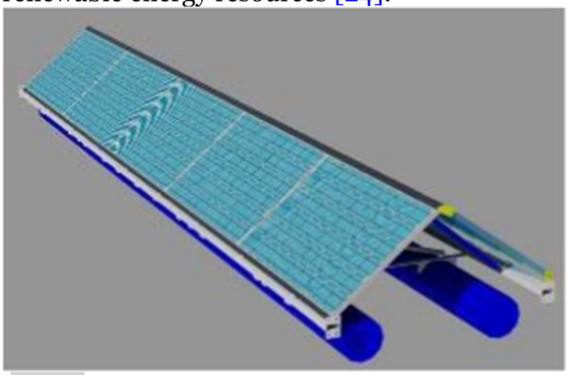

Fig. 5 Supporting Structure for Korea Project [24].

5.RESULTS AND DISCUSSION

The Homer program, a software application specifically designed to calculate and evaluate hybrid energy systems, was utilized. This process involves integrating multiple energy sources and analyzing data related to average temperatures, solar radiation duration, angle of incidence, wind speed, and other relevant factors in the study area. The program provides optimal solutions from various perspectives while prioritizing economic viability by considering system setup costs. Homer is an established tool for performing power and cost analyses based on several factors, such as wind speed, solar irradiance, and load profiles across numerous configurations. Several findings emerged by applying the Homer program to assess economic costs associated with implementing a solar electric system within Iraq's market context, alongside climatic data specific to Haditha Dam Lake. Figure 6, from the Homer program, illustrates the proposed site for the present study (Haditha Dam), showcasing geographical dimensions on a map along with latitude and longitude coordinates. The study also considered all information and influential factors to provide economic feasibility that improves and stabilizes the electrical power network in Iraq.

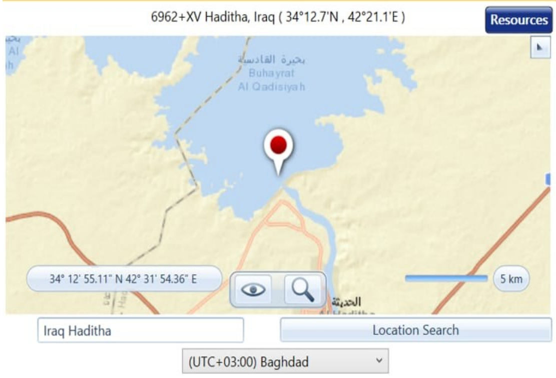

Fig. 6 Haditha Dam Site in Western Iraq.

Figure 7 depicts a single-line diagram of the proposed project for this study, as derived from the simulation results. This visual representation provides an overview of the project's layout and design based on data-driven insights obtained through in-depth analysis. Figure 8 shows the average annual solar radiation in the study area. This data offers valuable insights into seasonal variations in sunlight exposure, which can help inform strategies for optimizing solar panel efficiency and energy production across different periods. According to the inputs of the proposed floating system, the results were the average output of the energy produced per month from the floating solar panels. Figures 9 and 10 show the amount of daily energy that can be obtained. Figure 11 demonstrates the relationship between the amount of solar radiation incident on the panels and the energy produced per square meter.

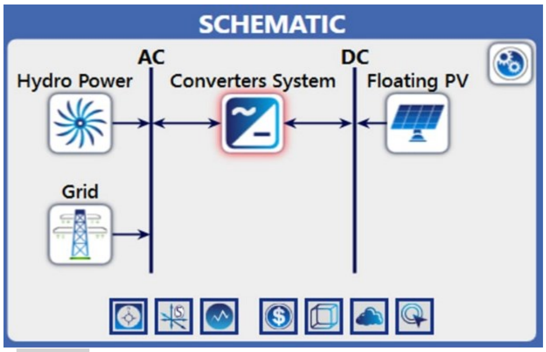

Fig. 7 Single-Line Diagram of the Proposed Project.

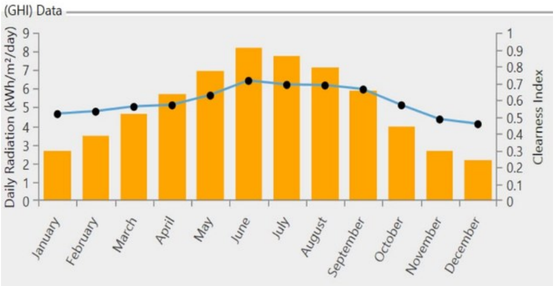

Fig. 8 Average Amount of Solar Radiation Falling on the Dam Lake in Each Month of the Year.

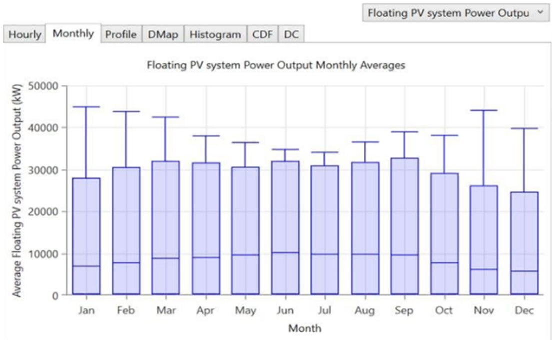

Fig. 9 Averages Output Monthly.

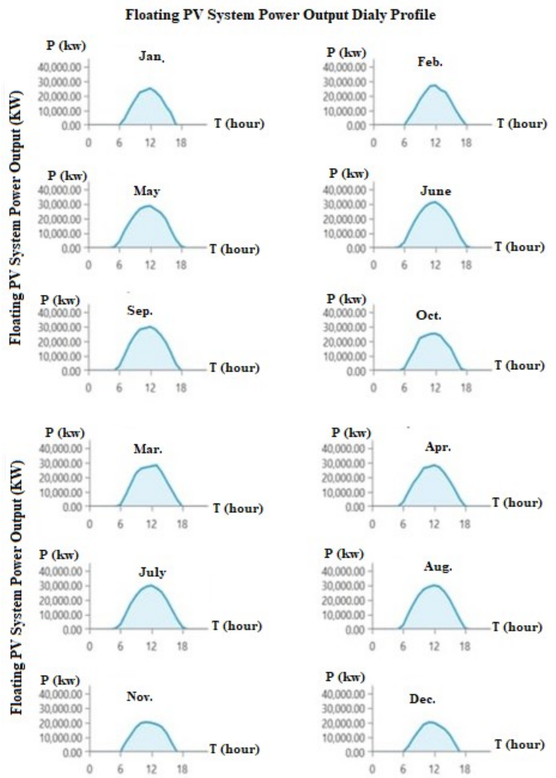

Fig. 10 Average Energy Produced Per Day for Days of the Year.

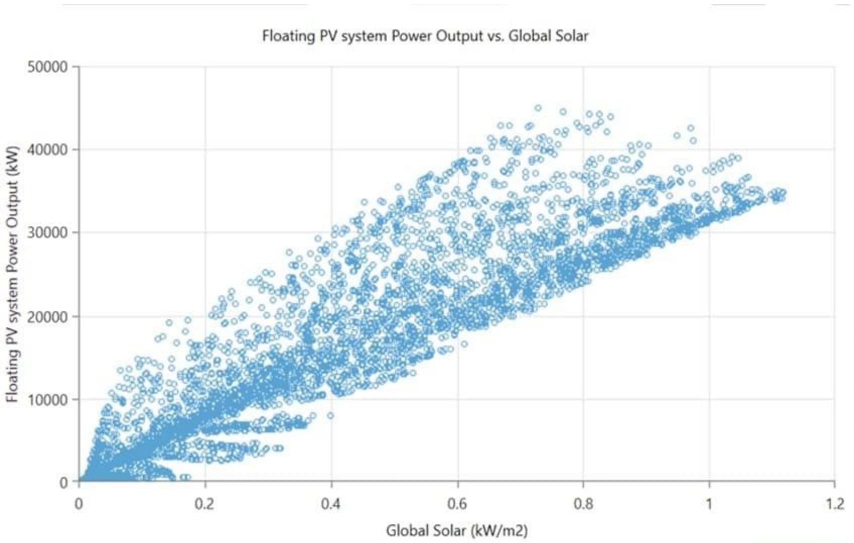

Fig. 11 The Relationship between the Amount of Incident Radiation and the Energy Produced by the Panels.

6.CONCLUSION

Implementing floating solar panels at the Haditha Dam Station in Iraq presents a promising solution to address the challenges of energy shortages and water evaporation. This study has explored various aspects of floating solar panel installations, including orientation, inclination angles, supporting structures, materials used, and modeling techniques. The Homer program simulation results indicated the proposed hybrid system's economic viability and positive impact. By harnessing solar energy through floating solar panels, the Haditha Dam Station can increase its energy production efficiency, preserve water resources, and contribute to the national grid. The results also provided feasibility for solving the energy shortage problem and preserving the dam lake's water reserve. Utilizing available water surfaces for these installations offers a sustainable and efficient approach to meeting increasing energy demands while conserving valuable water resources. Further research on this topic contributes significantly to the renewable energy transition within Iraq and other regions facing similar challenges.

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