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Analysis of the Potential Planning for Floating Solar Power Plants and Their Implementation at UG Techno Park Lake

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***Abstract**. Floating solar photovoltaic (PV) is an intriguing technology in renewable energy that offers innovative solutions to harness solar energy, expected to contribute to finding environmentally friendly and sustainable energy solutions. This research explores floating solar PV as an innovative technology for utilizing solar energy for sustainable and eco-friendly energy solutions. Key factors such as strategic location, area size, sunlight exposure, accessibility, and environmental impact are evaluated to analyze the potential use of UG TECHNO PARK Lake as a suitable location. The study aims to provide in-depth understanding of the benefits of floating solar PV and to formulate recommendations for its implementation as a step towards a more environmentally conscious society, with a primary focus on reducing the negative impacts of climate change and dependence on fossil fuels.*

***Keywords** Floating solar photovoltaic (PV), renewable, innovative, lake, recommendations, implementation, environment, climate.*

INTRODUCTION

Electricity generation is still dominated by the use of generators driven by turbines powered by steam pressure and water flow. Particularly in Java, specifically in West Java, several power plants have been operating for a long time to supply electricity, one of which is the Kracak Hydroelectric Power Plant (PLTA), which has been in operation since 1926.

Although PLTA Kracak has a long history and has significantly contributed to electricity supply, several issues have arisen concerning power generation. One of these issues is the aging equipment at PLTA Kracak, which has reached 86 years of operation. Despite still functioning well, concerns remain regarding its long-term durability and efficiency. Located in Kracak Village, Leuwiliang District, Bogor Regency, this hydroelectric power plant has been operating since 1926. With an installed capacity of 18.9 MW (3×6.3 MW), PLTA Kracak continues to generate electricity from the Cianten and Cikuluwung rivers (Gunawan et al., 2020).

In addition to PLTA Kracak, several other power plants are managed by the Saguling Power Generation Business Unit (UBP) of PT Indonesia Power. PLTA Kracak is one of

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the oldest power plants in Indonesia, yet it still operates effectively despite its long lifespan. Conventional hydroelectric power plants, such as PLTA Bengkok and Dago in Bandung, PLTA Parakan Kondang in Sumedang Regency, and PLTA Ubrug in Sukabumi, as well as three others in Bandung City—Plengan, Lamajan, and Cikalong—continue to function well and supply electricity (Venisia, 2014).

Although turbine-driven power plants have advantages such as energy efficiency, they also face challenges. One of these challenges for hydroelectric plants is the dry season when water supply decreases. Additionally, turbines driven by steam from coal or gas combustion also have relatively high operational costs. Therefore, developing more efficient and sustainable solutions to address these challenges is crucial for the power generation industry.

However, as conventional power plants remain operational, solar power plants (PLTS) emerge as a promising alternative to tackle energy challenges. Further research is needed to fully explore its potential in electricity generation (Sartika et al., 2023). PLTS represents one of the latest innovations in renewable energy. Solar panels use photovoltaic cells to convert sunlight into electricity. These panels are typically connected in series or parallel to increase power output (Diniardi et al., 2022).

However, in this context, temperature rise in solar panels can reduce their productivity, necessitating cooling to maintain optimal temperatures. Strategies are needed to address panel temperature increases due to sunlight exposure. This research involves various cooling methods, including ventilation systems and active cooling, while considering environmental factors such as installation location and sunlight intensity. Floating solar power plants (PLTS Apung) are thus used to mitigate these issues (Siswanto & Sukadana, 2021).

To improve efficiency and economic performance of solar panels, an alternative approach involves utilizing floating solar panels on water. In the floating solar panel concept, panels are placed on water surfaces such as ponds or lakes. The main advantage is that the solar panel temperature remains stable due to natural cooling from the water beneath. Without requiring active cooling systems, floating solar panels can reduce costs and energy consumption typically needed for conventional cooling systems (Diniardi et al., 2022).

Efficiency gains in floating solar power plants occur due to the temperature difference between water and land. Below the water surface, temperatures tend to be lower than on land or sand. This is due to the differing thermal properties of water and land. These temperature differences offer several advantages for floating solar power plants, including:

1. Efficient Cooling for Solar Panels: Solar panels achieve maximum performance at lower surrounding temperatures. This enhances efficiency since lower panel temperatures result in less energy wasted as heat. Floating on cooler water helps lower panel temperatures and increases efficiency in capturing solar radiation.
2. Stable Environmental Conditions: In aquatic environments, temperatures remain more stable compared to land, which experiences daily and seasonal fluctuations. Reduced temperature variations around floating solar panels help maintain panel performance and extend their lifespan.
3. Reduction of Global Warming Impact: The efficiency of floating solar power systems in capturing solar energy also helps reduce greenhouse gas emissions contributing to global warming. By generating electricity more efficiently, floating solar systems help reduce reliance on fossil fuel-based power plants, thereby lowering carbon emissions.
4. Optimized Land Use: One challenge in land-based solar power system development is the space required for panel installation. Floating solar power systems present an attractive alternative in areas with limited land availability but sufficient access to water bodies.

Floating solar power plants, as an alternative option, aim to enhance efficiency in capturing solar radiation compared to land-based or sand-mounted solar systems. Beyond providing energy efficiency advantages, floating solar panels also address several obstacles faced by land-based solar systems. Utilizing water bodies for solar panel installations enables optimal land use, especially in regions where land is limited or holds high economic value for other purposes. Additionally, floating solar power plants can help reduce water evaporation from surface water bodies, particularly in reservoirs or lakes, thereby increasing water availability for irrigation and community needs. With greater location flexibility, potential support for other renewable energy technologies, and contributions to environmental challenges, floating solar power plants offer a solution that (Ray et al., 2021).

Innovative Technology: Floating Solar Panels (PLTS Apung) have emerged as an attractive option. While promising significant potential for renewable energy, floating solar power plants also present some drawbacks that must be considered. One notable drawback is the relatively higher maintenance costs. However, the advantages of floating solar power plants in utilizing water areas and improving land use efficiency remain key positive factors.

The maintenance cost challenges of floating solar power plants mainly arise due to the novelty of the concept, requiring expert teams for upkeep.

Although maintenance costs are a concern, it is important to recognize that this drawback is outweighed by the benefits of floating solar power plants. Their main advantage is the ability to optimize underutilized water areas, enhance land-use efficiency, and provide greater energy potential. Thus, despite maintenance costs being a challenge, the benefits of floating solar power plants in resource utilization and energy potential are more significant. With technological advancements and growing experience, it is expected that maintenance costs can be reduced, and system efficiency improved (Nurjaman & Susandi, 2019).

In this exploration, it is acknowledged that maintenance, pollution management, water sedimentation, and ecological impacts of floating solar power plants require special attention. Therefore, a comprehensive approach and careful consideration are necessary to further develop this technology (Khalawi, M. R. F., Sriyana, S., & Nugroho, 2022).

Floating Solar Power Plants (FSPPs) have great potential to improve efficiency in capturing solar radiation and make a significant contribution to meeting sustainable energy needs. Therefore, it is essential to continue supporting the development of this technology through research and investment, to achieve a cleaner energy future. This study emphasizes the importance of analysis and investment in advancing floating solar power technology to achieve more sustainable energy goals (Venisia, 2014).

This writing aims to provide a deeper clarification regarding floating solar power plants, focusing on their advantages, disadvantages, and prospects. To evaluate the potential and relevance of this technology in supplying energy in an era increasingly shifting toward renewable energy sources, a comparison will be made between floating solar power plants and traditional power plants, including the Kracak Hydroelectric Power Plant (Khalawi, M. R. F., Sriyana, S., & Nugroho, 2022).

This study aims to evaluate the potential use of UG Techno Park Lake as a location for a floating solar power plant, which is considered an innovative solution for meeting energy needs using renewable resources. The analysis will compare the advantages and challenges of floating solar power plants with traditional solar power plants, taking into account factors such as location, area coverage, sunlight exposure, accessibility, and environmental impact. The results are expected to provide a deeper understanding of the benefits of implementing floating solar power plants in UG Techno Park Lake as an efficient and sustainable energy alternative.

Figure 1. Lake UG *TECHNO PARK* [6°45'47.0"S 107°12'33.6"E], citra from Google *Earth*

LITERATURE REVIEW

Floating Solar Power Plants (FSPPs) have gained significant attention as a viable alternative to traditional land-based solar installations. Research has shown that placing solar panels on water bodies can enhance energy efficiency due to the natural cooling effect of water. This reduces panel overheating, thereby increasing energy output compared to land-based photovoltaic systems. Moreover, floating solar panels provide an innovative solution to land constraints, particularly in densely populated or urban areas where space for solar farms is limited.

Several studies have explored the economic and environmental benefits of FSPPs. According to recent research, floating solar technology can reduce water evaporation, benefiting water reservoirs and lakes by conserving essential water resources. Additionally, it mitigates the urban heat island effect by lowering surrounding temperatures. The combination of solar energy generation and water conservation aligns with sustainable development goals, making floating solar systems an attractive option for renewable energy expansion.

Despite their advantages, implementing floating solar power plants requires addressing challenges such as installation costs, maintenance, and potential ecological impacts on aquatic ecosystems. Studies suggest that proper site selection and floating platform design are crucial to minimizing negative environmental effects. Furthermore, integrating advanced materials and monitoring systems can enhance the durability and efficiency of floating solar installations. As technology progresses, continued research and development are necessary to optimize the implementation of floating solar power plants, particularly in specific locations like UG Techno Park Lake.

METHODS

Weather and climate data collection is conducted at UG Techno Park Lake or Cikalong Village. This process involves receiving information from local weather stations and meteorological institutions. The gathered data includes solar radiation intensity, air temperature, humidity, and other climatic factors. This approach ensures that the analysis of solar radiation exposure is based on accurate and up-to-date data to evaluate the energy potential of floating solar power plants.

1. Evaluation of Solar Radiation Exposure:

In the initial research phase, meteorological and climatological data are collected in the UG Techno Park area or Cikalong Village. This process involves gathering data from various meteorological sources, such as weather stations or local meteorological agencies. The collected information includes key variables such as solar radiation intensity, air temperature, humidity, and other relevant climatological elements. Data collection is conducted over a carefully selected period, aligned with research requirements, to reflect the representative weather and climate conditions of the study location. This approach ensures that the solar radiation exposure analysis relies on accurate and up-to-date data, providing a strong foundation for estimating the potential energy that can be generated by the floating solar power system.

2. Estimating the Number of Panels to Achieve 1300 KWh Energy Production:

In the next phase, after collecting solar radiation exposure data, calculations are performed to estimate the total energy that can be generated by a single panel over a specific period. This process involves a mathematical analysis of the sunlight intensity received by the solar panels, considering factors such as efficiency and panel surface area. The calculation results provide deep insights into the energy capacity of each panel under specific conditions, serving as a basis for understanding the power potential of the floating solar power system at the research location and supporting the design of an efficient and optimal system.

After calculating the energy output of a single panel, the next step is to determine the total energy required to meet the target of 1300 KWh. This process involves mathematical calculations based on the daily energy demand set as the target. By comparing the total panel energy with daily energy needs, the estimated number of required solar panels can be determined. This approach provides a comprehensive overview of the floating solar power system requirements to achieve energy goals, forming the basis for designing an efficient system suited to the energy needs of the research location.

Constructing a water-based solar power generation system involves developing an infrastructure that utilizes water as a supporting medium for solar panels. This infrastructure can be established by installing solar panels on floating structures positioned on water surfaces, such as ponds or lakes. This design allows solar panels to follow the sun’s movement throughout the day, enhancing sunlight collection efficiency. Additionally, floating structures can act as heat absorbers, reducing panel overheating and improving overall system efficiency. The design process also includes selecting technology and components resistant to water exposure, along with precise calculations to ensure energy optimization in this water-based solar power system.

3. Construction Design of the Floating Solar Power System:

Developing a floating solar power system involves extensive research on construction and material selection for solar panels that will be deployed on a lake. This research focuses on analyzing resistance to water exposure and continuous wet conditions. The selection of corrosion-resistant and waterproof materials is crucial to ensuring the sustainable operation of solar panels in aquatic environments. Moreover, designing the solar panel construction requires considering aspects such as stability, resistance to water waves, and ecological impact on the lake ecosystem. The integration of construction research and material selection plays a key role in creating a strong, efficient, and environmentally friendly water-based solar power system.

Establishing an appropriate flotation design is essential to ensure the panels remain afloat on the water surface and operate with maximum efficiency.

RESULTS

At the UG Techno Park Lake or Cikalong Village location, meteorological and climatological data collection is conducted. This process involves acquiring information from weather stations and local meteorological institutions, covering variables such as solar radiation intensity, air temperature, humidity, and other climatological factors. This approach ensures that the analysis of solar radiation exposure is based on accurate and up-to-date data to estimate the energy potential of the floating solar power system. The data collection includes:

1. Analysis of Solar Radiation Exposure

In an effort to analyze solar radiation exposure at UG Techno Park Lake or Cikalong Village, this study involves a series of detailed steps. The first step includes collecting meteorological and climatological data from reliable sources such as local weather stations or national meteorological institutions. This data comprises key parameters such as solar light intensity, sunlight duration, and weather conditions over a specific period relevant to this research.

Once the data is gathered, the next step is to conduct an analysis to determine the average solar radiation exposure at the research site over a defined timeframe. The results of this analysis provide a clear overview of the expected level of solar exposure in the study area. Subsequently, this average solar radiation exposure will be correlated with the solar energy potential that can be generated by the floating solar power system. The main objective is to understand to what extent the solar radiation conditions at the site can support the productivity of the floating solar power system.

In evaluating the feasibility of the floating solar power system in this region, particularly in Cianjur, West Java, this study details data from id.weatherspark.com1 to predict the conditions for 2024. The analyzed data includes information on climate, hourly average temperatures, day and night conditions, sunrise and sunset times, as well as solar elevation and azimuth throughout the seasons in Cianjur. The data illustration can be seen in the figure below:

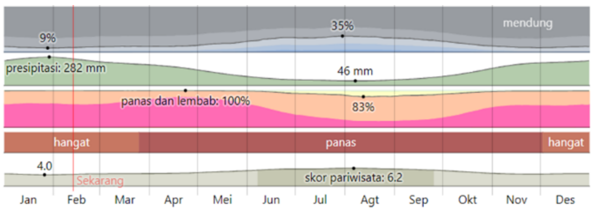


Figure 2. The climate in Cianjur.

From Figure 2 above, Cianjur experiences a short and hot summer, while the winter season tends to be short and warm. Overall, the weather in this region is generally hot, with moderate rainfall of around 40% and frequent cloud cover throughout the year. The average annual temperature ranges between 19°C and 31°C, rarely dropping below 18°C or rising above 33°C.

As seen in Figure 3, a brief characterization of the average hourly temperature throughout the year is presented. The diagram below visualizes each day of the year on the horizontal axis, while the vertical axis represents the hours of the day. The colors displayed on the diagram reflect the average temperature at specific hours and days. With this visual representation, annual temperature patterns can be quickly identified, including daily changes and temperature variations at different times of the day. This figure provides a comprehensive overview for analyzing and understanding temperature dynamics throughout the year and serves as a useful tool for detailing daily and seasonal temperature changes while highlighting key aspects of a region's climate characteristics.

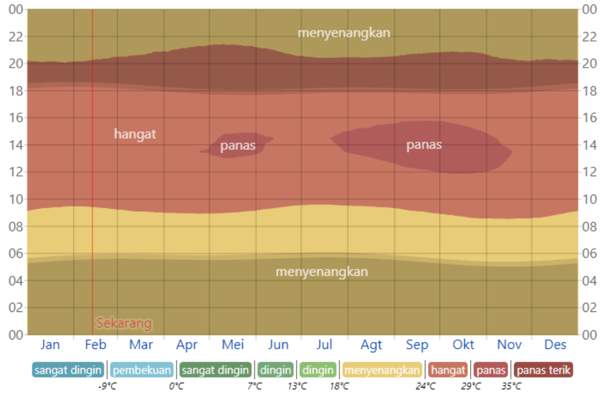


Figure 3. Average hourly temperature in Cianjur.

In Figure 4, sunlight exposure is illustrated. The diagram of day and night duration as a characteristic of the days in Cianjur shows limited differences between day and night throughout the year, which has significant implications, particularly in the context of nighttime electricity usage. With the shortest day occurring on June 21 and the longest day on December 21, changes in daylight duration can affect the community's electricity consumption patterns.

On June 21, when daylight duration is shorter, there is a potential increase in electricity consumption at night. This is due to the increased need for artificial lighting and household energy as night falls earlier. Conversely, on December 21, with longer daylight hours, people tend to utilize sunlight for a longer period for lighting and daily activities, thereby reducing electricity demand at night.

A deeper understanding of the characteristics of day and night duration can help in planning and managing energy distribution, particularly during nighttime. Electricity providers can optimize their resources and infrastructure to address fluctuations in electricity demand due to changes in daylight duration. On the other hand, the public can be guided to adopt more efficient and sustainable energy usage habits, helping to reduce the load on the electricity system at night. Therefore, the relationship between daylight duration and electricity consumption can serve as a basis for more effective energy management strategies in Cianjur.

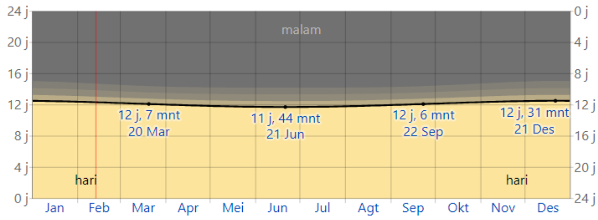


Figure 4: The black line represents the number of sunlight hours, while the colored band ranging from yellow to gray illustrates the transition from full daylight to full night.

In exploring the characteristics of solar time in Cianjur, Figure 5 below presents a visualization of the changes in sunrise and sunset times throughout the year. This explanation provides an overview of the moments of sunrise and sunset, covering the time span across the year. Recorded data shows that the earliest sunrise occurs on November 12 at 05:23, while the latest sunrise happens 41 minutes later on July 16 at 06:04. The earliest sunset is recorded on May 24 at 17:41, while the latest sunset occurs 35 minutes later on January 31 at 18:16. Thus, this visualization provides a deeper understanding of the variations and dynamics of solar time in this location.

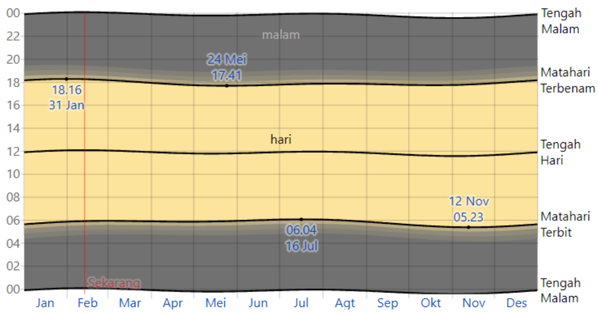


Figure 5. Sunrise & Sunset with Nighttime in Cianjur.

The diagram in Figure 5 depicts the movement of the sun throughout the day in 2024. The black line moves from bottom to top, covering the previous midnight sun, sunrise, solar noon, sunset, and the next midnight sun. The color band ranges from yellow to gray, distinguishing daylight, twilight (in three phases: civil, nautical, and astronomical), and nighttime. With this visualization, the journey of the sun and the changes in light conditions and time can be graphically understood throughout the day.

Furthermore, factors affecting the efficiency of electrical energy conversion from solar radiation involve solar elevation and azimuth. In this visualization, the horizontal timeline reflects changes in the sun's position throughout the year, providing an overview of solar movement and variation over a specific period. Meanwhile, the vertical axis represents variations in solar elevation from morning to evening, offering a vertical perspective on the sun's height at different hours of the day.

At specific points in the graph, the background color provides clues about the sun's orientation at that moment, offering insights into the sun's direction at crucial points throughout the day. Additionally, black isolines depict contours of constant solar elevation, visualizing points where the sun reaches the same elevation at specific times. This provides a visual representation of the sun's ascent or descent in the sky at key moments, such as sunrise or sunset.

With this approach, the graph not only presents data in horizontal and vertical dimensions but also integrates it into a visual format that provides a deep understanding of the sun's dynamic changes over time. In the context of this study, this representation serves as an effective tool for understanding climate changes and lighting conditions in a specific region during the designated reporting period, as illustrated in Figure 6 below.

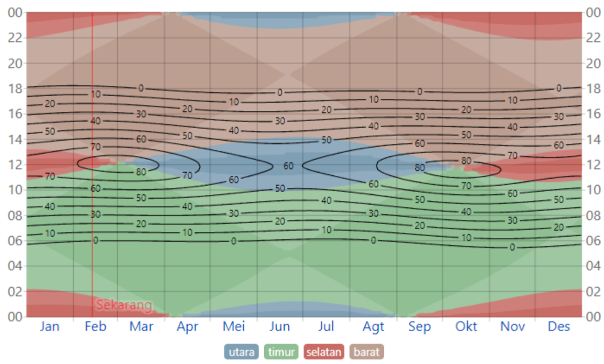


Figure 6. Solar Elevation and Azimuth Degrees Throughout the Seasons in Cianjur.

In Figure 6, the solar elevation and azimuth throughout the year 2024 are depicted. The black line represents the constant solar height line, measured in degrees, providing information about the sun's angle above the horizon. The background color in the graph reflects the azimuth (compass direction) of the sun. The bright-colored areas at the boundaries of the cardinal compass points offer implied directional cues, such as northeast, southeast, southwest, and northwest.

This graph serves as an effective visual tool for understanding the elevation and direction of the sun throughout the year. By focusing on the time range between 08:00 and 16:00, this graph provides a detailed illustration of the optimal sun position for illuminating solar panels at elevations between 30 and 80 degrees. This information is crucial for optimizing solar energy capture efficiency, particularly during this period.

DISCUSSION

Meteorological and climatological data were collected at UG Techno Park Lake or Cikalong Village as the initial step of the research. The data collection included key variables such as solar radiation intensity, air temperature, and humidity. This information provides a solid foundation for designing an efficient and optimal floating solar power plant (PLTS) system. By considering the correlation between average solar radiation exposure and solar energy potential, this study impacts the design of the PLTS system at the site.

An evaluation was conducted to determine the optimal design of the solar panel construction and its supporting components. This step is crucial to ensure that the planned floating PLTS system efficiently utilizes solar energy potential, in accordance with the previously analyzed local environmental conditions. Information from meteorological and climatological data serves as the basis for determining the size and capacity of solar panels, energy storage batteries, and other components suited to the solar radiation characteristics of the research location. Through this analytical approach, the study aims to provide a comprehensive understanding of the solar energy potential at the study site, supporting the implementation of a sustainable and effective PLTS system. Further planning of the equipment includes:

1. Estimation of Solar Panel Quantity to Achieve 1300 kWh

In the development of sustainable energy systems, PLTS design analysis is a key step in establishing an efficient and environmentally friendly infrastructure. The primary focus of this research is to calculate the number of PLTS panels required to generate 1300 kilowatt-hours (kWh) of energy. This explanation will outline the process of calculating the total energy needed while considering factors such as efficiency and panel capacity. The analytical steps implemented aim to achieve the energy target while accounting for both technical and economic aspects. This study not only presents quantitative analysis but also reflects a comprehensive effort to design a sustainable energy solution.

In evaluating the number of solar panels and battery capacity required to meet a daily power demand of 1300 kWh, this analysis assumes an effective average solar exposure of 7 hours per day. An additional assumption in this study is that lighting duration is 12 hours per day. Based on these assumptions, the analytical steps carried out are expected to provide a comprehensive understanding of the number and capacity of solar panels and batteries required to meet the specified daily energy target, as follows:

The daily target of 1300 kWh is the primary focus of this analysis, with the initial step being to calculate daily energy needs. This determination uses a general formula where Daily Energy Demand is derived from multiplying Daily Power by Operating Time. To obtain the peak power demand of solar panels, the Peak Solar Panel Power formula is used. This formula is calculated by dividing the Daily Energy Demand by the product of Solar Panel Efficiency and Solar Exposure Time. The fundamental assumption in this study is a solar panel efficiency of 80%, representing a conservative yet realistic efficiency level for daily use. This analysis aims to provide an accurate and measurable calculation basis for determining energy needs and peak solar panel power to achieve the daily target of 1300 kWh.

Calculate Daily Energy Demand:

Daily Energy Demand = Daily Power × Operating TimeDaily Energy Demand = 1300 kWh × 8 hoursDaily Energy Demand = 10400 kWh

Calculate Peak Solar Panel Power:

Peak Solar Panel Power = (Daily Energy Demand) / (Solar Panel Efficiency × Solar Exposure Time)Solar Panel Efficiency = 10% (general assumption)Peak Solar Panel Power = (1300 kWh) / (0.12 × 8 hours)Peak Solar Panel Power ≈ 1354 kW

The next critical step in designing an efficient solar power plant (PLTS) system tailored to daily energy needs is calculating the number of solar panels required. This research aims to provide a comprehensive calculation to obtain an accurate estimate of the solar panel capacity needed to meet the 1300 kWh daily energy demand. By considering technical aspects such as solar panel efficiency, solar exposure time, and standard solar panel size, this analysis establishes a solid foundation for selecting and configuring solar panels to support sustainable energy supply. Let us explore the calculations involved in determining the optimal number of solar panels required to achieve the set energy goal:

Number of solar panels = (Peak Solar Panel Power) / (Standard solar panel size (300 watts per panel))With a standard solar panel size of approximately 1 meter × 2 meters.

Number of solar panels = (1354 kW) / (1.96 m^2)Number of solar panels ≈ 690.8, rounded to 691 panels

The initial estimate indicates that approximately 691 solar panels, each with a capacity of 300 watts, are required to meet the daily energy demand of 1300 kWh. This figure provides an initial basis for determining the number of solar panels needed in a specific configuration.

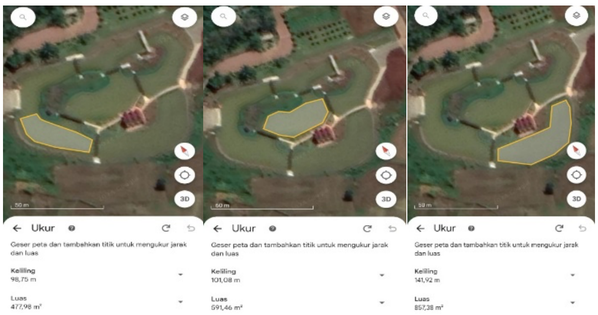
The next step after determining the number of solar panels in designing a floating solar power plant (PLTS) system is calculating the required water surface area. This research aims to provide an area estimation needed to accommodate standard-sized solar panels measuring 1 meter × 2 meters, equivalent to 1.96 m^2 per panel. Considering practical and operational efficiency aspects, this analysis provides crucial information in designing an effective and environmentally friendly PLTS system. The calculation of the required water surface area to accommodate solar panels in the standard configuration can be determined as follows:

Water Surface Area = Number of Solar Panels × Area of One Solar PanelWater Surface Area = 691 panels × 1.96 m^2 (per panel)Required Water Surface Area ≈ 1354.36 m^2

The estimated surface area of UG Techno Park Lake, as seen in Figure 1, was calculated using Google Earth and resulted in an approximate value of 5776.62 m², as illustrated in Figure 7 below.

Figure 7. Area of UG *TECHNO PARK*

Conversely, to calculate the water surface area, it is necessary to subtract the land area within the lake. This calculation can be seen in Figures 8A, B, and C below.



A B C

Figure 8. Water Surface Area for Solar Panel Placement (A= 477.98 m^2, B= 591.46 m^2, C= 857.38 m^2).

The calculation of the water surface area for solar panel placement, when summed, results in a total of approximately 1926.82 m², consisting of 477.98 m², 591.46 m², and 857.38 m². However, calculations show that the required water surface area is around

1354.36 m^2. Thus, the available water surface area in part of the lake is sufficient to accommodate 691 solar panels, each measuring 1x2 meters per panel.

In the context of estimating the number of panels needed to generate 1300 kWh, the calculation of battery capacity is a crucial aspect to ensure a continuous energy supply, especially during periods without sunlight exposure. This study presents detailed calculations of the required battery capacity to support operations for 12 hours, assuming 8 hours of sunlight exposure. Considering the Daily Energy Demand of 1300 kWh, this analysis provides a solid foundation for determining the optimal battery capacity to maintain energy availability under specific operational conditions. Let's explore the calculations involved in ensuring energy sustainability through battery capacity estimation that aligns with daily energy needs:

Battery Capacity Calculation:Battery Capacity = Daily Energy Demand × (Operating Time − Sunlight Exposure Time)Assuming a Daily Energy Demand of 1300 kWh, an Operating Time of 12 hours, and a Sunlight Exposure Time of 8 hours:Battery Capacity = 1300 kWh × (12 hours − 8 hours)Battery Capacity = 5200 kWh

2. Design and Planning of Floating Solar Power System Construction

In the exploration of renewable energy, floating solar power plants (PLTS Apung) have become an attractive option despite facing challenges in construction and sustainability in wet environments. This study delves into crucial aspects of floating solar power plant design, particularly concerning construction and material selection. The solar panel floaters use Polyethylene (PE) or Polypropylene (PP) as economical and corrosion-resistant options. These materials, being lightweight and durable, are considered suitable for aquatic environments.

The primary focus of the analysis is to understand the environmental impact on solar panels in water and to seek construction and material solutions that are waterproof and sustainable. In the planning stage, the solar panels are designed to have a per-panel capacity that generates a peak power output of 1354 kW with:

Thin-Film Solar Panel (CdTe):Dimensions: 1 x 2 metersEfficiency: Average 9-12%Weight: Approximately 15 kilograms

Figure 9. Floater Design for Floating Solar Panels.

To ensure the safety of solar panels while floating, Archimedes' principle can be applied to calculate their buoyant force:

Submerged Volume (Solar Panel Volume)

$V_{submerged}$ = (Panel weight) / (Water density)

$V_{submerged} = (15\ kg) / (1000\ kg/m^3)$

$V_{submerged} = 0.015\ m^3$

Buoyant Force Calculation

$F_{buoyant} = \rho_{water} \times V_{submerged} \times g$

$F_{buoyant} = (1000\ kg/m^3) \times (0.15\ m^3) \times (9.8\ m/s^2)$

$F_{buoyant} = 147\ N$

Comparison with Panel Weight

$F_{buoyant} \geq$ Panel Weight

$147\ N \geq 15\ N$

By comparing the solar panel's weight (15 N) with the buoyant force generated (147 N), it can be concluded that the buoyant force is more than sufficient to support the panel's weight. In other words, a 15 kg solar panel will experience a buoyant force greater than the downward gravitational force acting on it.

This demonstrates that the solar panel will safely float on the water surface because the generated buoyant force is sufficient to balance its weight. This ensures that the solar panel can remain in an aquatic environment without the risk of sinking, thereby ensuring operational sustainability and the safety of the device in floating solar power plant (PLTS Apung) applications.

By comparing the weight of the solar panel itself (15 N) with the buoyant force generated by the solar panel (147 N), it can be concluded that the buoyant force is more than sufficient to support the panel's weight. In other words, a 15 kg solar panel will experience a buoyant force greater than the gravitational force acting downward on the panel.

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CONCLUSION

By comparing the weight of the solar panel itself (15 N) with the buoyant force generated by the solar panel (147 N), it can be concluded that the buoyant force is more than sufficient to support the panel's weight. In other words, a 15 kg solar panel will experience a buoyant force greater than the gravitational force acting downward on the panel. This indicates that the solar panel will safely float on the water surface because the generated buoyant force is sufficient to balance its weight. This ensures that the solar panel can remain in an aquatic environment without the risk of sinking, thereby guaranteeing operational sustainability and the safety of the device in floating solar power plant (PLTS Apung) applications.

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