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2023 International Conference on Smart-Green Technology in Electrical and Information Systems (ICSGTEIS)

WELCOME MESSAGE

It is my pleasure to extend a warm welcome to all participants of the 2023 International Conference on Smart Green Technology in Electrical and Information Systems (ICSGTEIS 2023), taking place in Bali, Indonesia from November 2nd through November 4th, 2023. The purpose of the conference is to provide a platform for the exchange of findings, ideas, innovations, and visions related to smart and green technologies. The 2023 ICSGTEIS is being presented in a hybrid format, and is being arranged by the Department of Electrical Engineering and the Postgraduate Study of Electrical Engineering at Udayana University's Faculty of Engineering.

The ICSGTEIS 2023 accepted submissions from multiple fields, including Power, Energy, and Industry Applications; Engineered Materials, Dielectrics, and Plasmas; Fields, Waves, and Electromagnetics; Signal Processing and Analysis; Communication, Networking, and Broadcasting; Robotics and Control Systems; Photonics and Electro-Optics; Computing and Processing (Hardware/Software); Software Engineering, and Information Systems. Each submission underwent a peer review process for acceptance. The conference received 80 submissions, with only 46 being chosen for presentation. In addition to the paper presentations, the program features plenary keynote speeches, gala dinner and social events.

I would like to thank Professor Jean-Marie Bonnin of IMT Atlantique & Irisa, France, for sharing his latest perspectives and research in the field of Smart Mobility Technologies and Professor Arif Nur Afandi of State University of Malang, Indonesia for providing insight on Energy & Power Systems.

I would like to express my gratitude to the IEEE Indonesia Section, the IEEE Udayana University Student Branch, Center for Community-Based Renewable Energy (CORE) Udayana University, and Udayana Center for Learning Innovation in Asia Pacific (UCLIAP) for their constant support of the conference.

Additionally, I extend my thanks to the International Advisory Board, the Technical Program Committee, and the Organizing Committee for their diligent efforts in coordinating the conference. Last but not least, gratitude is extended to all the presenters and authors who have selected ICSGTEIS 2023 as their platform for disseminating their research. Their participation has been instrumental in making this conference a reality.

I wish all conference attendees a productive and gratifying experience.

Best regards,

Dr. Ngurah Indra ER, MIEEE
General Chair of ICSGTEIS 2023

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Potential of Floating Photovoltaic System at Tanjungan Dam Mojokerto, Indonesia

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***Abstract*—This work simulates and investigates the feasibility of floating photovoltaic (FPV) system implementation at the existing dam, located in Tanjungan Mojokerto in East Java, Indonesia. The objectives of the work is to estimate the possible capacity of PV system on the area of the dam, as well as FPV's energy output. Google Earth and SolarGIS' PV Planner were used to simulate the system. It was found that about 61,650 m^2 area of the dam is available for module's placing, with of approximately capacity of 3.28 MWp. This size of PV system can produce approximately 24 GWh of energy per year.**

Keywords*— *FPV, dam, Tanjungan, solar energy

I. Introduction

Fossil energy is one of the main causes of global warming, due to the greenhouse gas emissions that are produced by burning hydrocarbon fuels. Fossil energy resources, such as coal, oil, and gas, are also being depleted. To ensure sustainability, we need to look for alternative clean energy resources. Photovoltaics (PV), which produce electricity from solar energy, is one of the most promising and environmentally friendly resources that can reduce fossil-based energy consumption [1], [2] .

Indonesia is a country that has many kind of renewable resources including geothermal, hydropower, biomass, and solar energy. So far, hydropower and geothermal are the main sources of renewable energy in Indonesia, particularly for electricity production. Solar photovoltaics, one of many renewable energy sources, that targeted to generate about 6.5 GW out of the 45 GW total by 2025[3], [4] .

The limitation of using solar PV systems, especially on a larger scales, is that they require land or open space for mounting solar panels. PV system that produces 1MWp will need approximately 10,000 m^2 of open space [5]. When the land is used for the PV system, it would also be inaccessible to other uses. The government of Indonesia has encouraged rooftop PV systems, but they can only provide a small part of the system's generation.

The Floating photovoltaic (FPV) solar system is a kind of solar farm built on surface water. This type of PV system is one of most promising solutions for expanding the solar energy industry.The FPV systems can be installed in coastal areas, lakes, dams and ponds. Through FPV installation, there are new opportunities to increase the capacity of solar electricity production. Installation FPV systems generally consist of a floating structure (or pontoon), an anchor system, cables and components. Figure 1 is a typical schematic diagram of an FPV system [6].

There were many studies and implementations of FPV around the world [Reff]. Various topics of studies on FPV were reported in the lireatures, including: Field experience and performance analysis of floating PV technologies in the tropics [7]; Design and installation of floating type photovoltaic energy generation system using FRP members [8]; Review of floating photovoltaic power plant [9]; Environmental impacts and benefits of marine floating solar [10] ; Hybrid floating solar photovoltaics-hydropower systems: Benefits and global assessment of technical potential [11]; Floating PVs in terms of power generation, environmental aspects, market potential, and challenges [12]; Use of floating PV plants for coordinated operation with hydropower plants: Case study of the hydroelectric plants of the São Francisco River basin [13].

For the Indonesian case, however, there have been fewer studies on FPV implementation reported [14], [15] . This work examines the FPV system implementation possibility on existing dam in Tanjungan, Mojokerto, Indonesia. Tanjungan Dam is a water reservoir that blocks the small surounding small river's flow. It is located in Mojokerto East Java Province of Indonesia. The reservoir water is drawn from the river and then added to the rainwater. The dam was built in 2008 and began operation in 2012. The dam's primary functions are:

- Flood control
- Irrigation water in dry season
- Tourism and inland fishing.

This study aims to estimate and determine the FPV system capability that could be used in the Tanjungabn Dam area. The electricity can be exported to the exsisting grid.

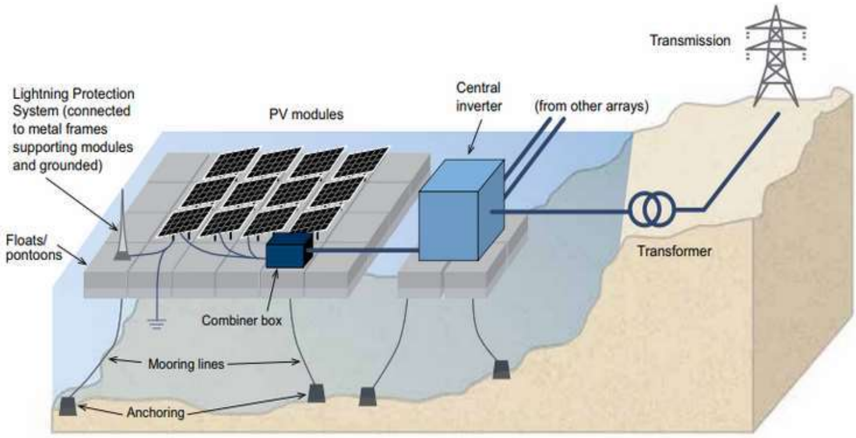

Fig 1. Typical schematic diagram and components of a FPV [6]

This is one of the many advantages of such electricity generation system.

II. Methods

Google Earth TM uses the Polygon feature to determine the total surface area of the water [16]. The effective area of solar modules is considered about 50% of the total water surface. Figure 2 shows the total area of water generated with Google Earth software.

The amount of energy generated by FPV system is estimated with simuation using SolarGIS Pvplanner software. The software simulation is available online [Reff]. The software simulates the databases of the climate and parameters input numerically. Astronomical possition of the simulated location is 7deg22'58.95S; 121deg24'01.46"E. Climate data for the simulation process is automatically recorded in the databases. They were derived from the actual climate data recorded by the nearest weather station.

Simulation is carried out with a 1000 Wp PV system capacity with a grid-connected system. This number is used to obtained the specific energy output (SEO) value of PV system in the location. The SEO value indicates the output energy of a PV system in comparison to the total solar irradiation fall in to the solar panels under the real operating conditions. The SEO value can be determined by comparing the energy output of PV system Eo, with the optimum power generation capability Po, under standart test conditions, in terms of kWp. The unit SEO is therefore kWh/kWp. Mathematically, it can be written as:

$$SEO = \frac{Eo,AC}{Po,STC} \text{...... (1)}$$

Fig 1. **Fig 2**. Tanjungan Dam on Google Earth view

Where:
SEO = specific energy output
Eo, AC = energy output at actual condition
Po,STC = power capability on standard test conditions.

The value of SEO can then be used to estimate the potential energy output for any scale of PV system. Panel array is a type of mounting for PV systems that simulates a panel arrangement. This means that the panels are free-standing and can be mounted at any angle. The optimal tilt ussualy depends on the geographic position. For the simulation for the location in this study, the panel tilt of 12° was taken, with azimuth angle of 0° or facing North.

III. Results and Discussions

Many factors affect the availability solar irradiation at a specific site, including the annual path of the Sun, solar radiation, humidity, temperature, albedo. The Sun path provides information about the sun's position over the course of a year. Figure 3 (left) shows the Sun path in Tanjungan. The figure also shows the module horizons & the terrain, and active areas with the civil and solar civil times. The annual Sun zenith angle variation for Tanjungan's long day is shown in Figure 3 (right). It can be seen that the length of the astronomical day would be shorter if there was a higher terrain obstruction.

Figure 4 shows the annual global solar radiation in Tanjungan on horizontal surfaces. The figure shows the level of global irradiation. It is composed of direct, diffuse, and reflected irradiation's components. It is obviously seen that the diffuse component is dominant in November-December and January-April. The reflected radiation component remains small throughout the year. Simulation results show that Tanjungan's maximum solar radiation was 4.58 kWh/m^2 in September and 2.43 kWh/m^2 in January. Over a year, the daily average is 3.53 kWh/m^2. The solar radiation in Tanjungan is generally less than the surrounding areas in the same province like Surabaya [15]. Tanjungan is a mountain region where fog forms during the day. It is a mountain area where fog forms during daytime

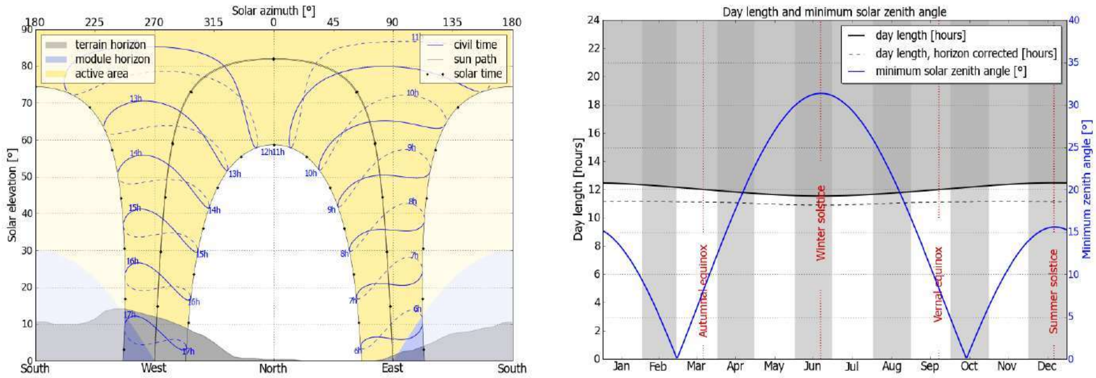

Fig 3. Terrain horizon and day length

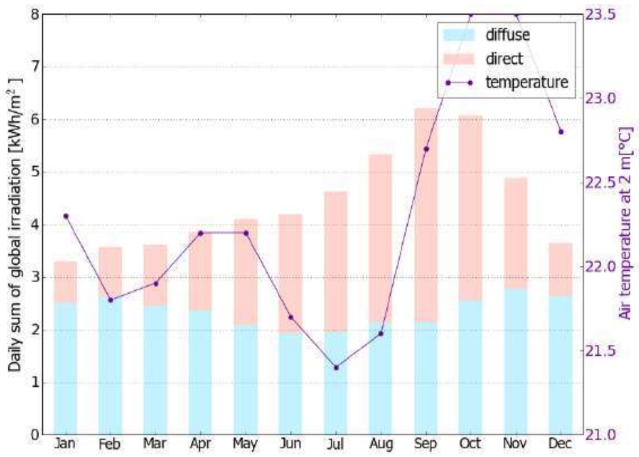

Fig 4. Global solar irradiation

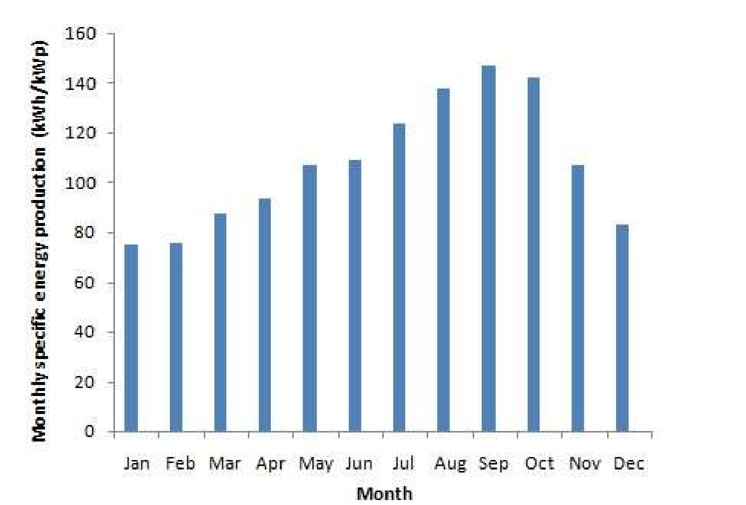

Fig 5. Monthly specific energy output
Global solar irradiation

Figure 4 shows the global solar irradiation for specific month in Tanjungan each for direct, diffuse, and reflected irradiation components. On the right vertical axis of the figure, it shows the mean air temperature. The temperatures varies between 21.4 and 23.5 °C. The temperature in Tanjungan is relatively low in camparison to the other surrounding area of tropical regions because it is close to the mountain area.

The Polygon Feature in Google Earth software is used to determine the surface area of the water dam as shown in Figure 2. The total area of the water surface was found about 61,650 m2. The total area may not be used completely for placing solar panels system, as the dam is also used for floating structure and other other purposes.

By assuming that 50% of the water area is used for FPV, the area available for the components and solar module placement would be approximately 30,500 m^2. According to previous studies [17], [18], a 1kWp with a fixed solar panel system (without any tracking system), would need around 9.2 m^2 space. Then, the solar FPV system with a capacity of 30,500/9.2 = 3,315 kWp (or 3,32 MWp) could be installed on the dam.

Simulation results show that the specific energy output, the mothly SEO of PV system in Tanjungan ranges from 76.2 kWh/kWp to 147.2 kWh/kWp. The highest output is in September, while the lowest output is in January. Figure 5 shows the details of Tanjungan's monthly specific energy output. The average energy output is 105 kWh/kWp. It is obvious seen that Figure 5 shows a direct correlation between the specific energy output and global horizontal radiation in Figure 4.

One can calculate the potential energy production from FPV by comparing the power output of the PV system with the capacity. If Tanjungan dam is equipped with a 3.32 MWp FPV system, the monthly energy production from the system will range from 250 MWh in January, to 480 MWh in September. The annual energy production would reach 24 GWh.

IV. Conclussions

The simulations of FPV system at Tanjungan Dam, East Java (Indonesia) has been presented. The dam's total water surface is found approximately 61,650m2. If we consider that a half of the total area of the water would be used for placing solar panels, then approximately 3.32 MWp FPV system would be able to install. The average monthly specific energy output in Tanjungan is found around 105 kWh/kWp. The annual energy production by the FPV system is approximately 24 GWh. One of the advantage of the FPV system is it can be hybrid with any other kind of electricity power generation, moreover with the existing power grid.

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