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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 & Irista, 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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TABLE OF CONTENTS

Copyright Page.....	i
Welcome Message	ii
International Advisory Board	iii
Organizing Committee.....	iv
Technical Program Committee	v
Table of Contents.....	vii
AI-Facilitated Ambient Factor-Based Annealment and Resiliency Sufficiency in Austere Locales.....	1
<i>Steve Chan</i>	
Design and Evaluation of an AR-Based Maintenance System for a Steam Jet Ejector of a Geothermal Power Plant	7
<i>Nur Cahyo, Ajay Irdan Noorwachid, Yunus Afandi, P. Paryanto, Rusnaldy, Andiko Mohammad Novriza</i>	
Potential of Floating Photovoltaic System at Tanjungan Dam Mojokerto, Indonesia....	13
<i>Elieser Tarigan</i>	
Design of Output Voltage Control for Dual-Active Bridge of Solid-State Transformer in Indonesia.....	18
<i>Muhammad Ridwan, Yohan Fajar Sidik, Sriyono, Kevin Gausultan Hadith Mangunkusumo, Rifka Widyastuti, Fransisco Danang Wijaya, Guntur Supriyadi, Lathief Wijaya</i>	
Advancing Total Communication in SIBI: A Proposed Conceptual Framework for Sign Language Translation.....	23
<i>I Dewa Made Bayu Atmaja Darmawan, Linawati, Gede Sukadarmika, Ni Made Ary Esta Dewi Wirastuti, Reza Pulungan, Mulyanto, Ni Kadek Dessy Hariyanti</i>	
Evaluation of Enrichment in Ontology-Based Knowledge Management System.....	29
<i>Ni Kadek Dessy Hariyanti, Linawati, I Made Oka Widyantara, Nyoman Putra Sastra, Anang Kukuh Adisusilo, I Wayan Budi Sentana, I Dewa Made Bayu Atmaja Darmawan</i>	
Classification of Tuna Meat Grade Quality Based on Color Space Using Wavelet and k-Nearest Neighbor Algorithm.....	35
<i>I Gede Sujana Eka Putra, I Ketut Gede Darma Putra, Made Sudarma, Anak Agung KOMPIANG Oka Sudana</i>	
Website Main Content Extraction Using Template-Based Approach and Naïve-Bayes Classification	41
<i>Nur Aini Rakhmawati, Fajara Kurniawan</i>	
Comprehensive Taxonomy and Advancements in IoT Device Authentication Schemes	47
<i>Saad El Jaouhari</i>	

Design of Controller Area Network (CAN) Communication for PWM Rectifier Control Hybrid Train	53
<i>Mudarris, Fransisco Danang Wijaya, Eka, Yohan Fajar Sidik, Musyaffa' Ahmad, Sigit Doni Ramdan</i>	
U-Net Wildfire Classification in Sumatra Island Based on Sentinel-2 and Landsat-8 Satellite Images.....	59
<i>I Made Murwantara, Marcellinus Aditya Witarsah, Robertus Hudi</i>	
An Adaptive Dynamic Bandwidth Management Model for Smart Building Systems Using Elastic WLAN Mechanisms	65
<i>I Putu Sudharma Yoga, Gede Sukadarmika, Ngurah Indra ER, Linawati, I Nyoman Budiastira</i>	
Stabilization of THz Waves Using Chaos Supremacy	71
<i>Fumiyoshi Kuwashima, Mona Jarrahi, Semih Cakmakyapan, Kenji Wada, Masanobu Haraguchi, Yuki Kawakami, Takeshi Moriyasu, Osamu Morikawa, Kazuyoshi Kurihara, Hideaki Kitahara, Takashi Furuya, Makoto Nakajima, Masahiko Tani</i>	
Enhancing Wind Tunnel Data Classification Through Effective Data Preprocessing for Machine Learning Algorithm Modeling.....	76
<i>Purwadi, Andani Ahmad, Ivransa Zuhdi Pane, Syafaruddin Syafaruddin</i>	
The Image of Tourist Attraction in Bali Based on Big Data Analytics and Sentiment Analysis.....	82
<i>Ni Wayan Sumartini Saraswati, I Ketut Gede Darma Putra, Made Sudarma, I Made Sukarsa</i>	
A Fine-Tuned BERT-Based Approach for Sentiment Analysis of Indonesian Public Towards ChatGPT.....	88
<i>I Wayan Agus Surya Darma, Putu Riky Mahendra Putra, Putu Sugiartawan, Valentino Waas, Ni Putu Sutramiani</i>	
SIBI Syllable Recognition System With LSTM	94
<i>Juli Sulaksono, Ida Ayu Dwi Girinatari, Made Sudarma, Ida Bagus Alit Swamardika</i>	
The Mediating Effect of Accounting Practices in the Relationship Between GreenTech and Carbon Emissions.....	98
<i>Thabit H. Thabit, Jalal J. Aleiwi, Omar S. Azeez, Hashem M. Safi, Manaf B. Raewf</i>	
Diabetic Foot Ulcer Detection on Mobile Platforms Through Thermal Imaging and Deep Learning	104
<i>Fitri Arnia, Khairun Saddami, Rusdha Muharar, Dea Ananda Dwi Pratiwi, Yudha Nurdin</i>	
Activity Prediction in Tri Pramana Learning Concept in ResNet-Based Virtual Reality Environment.....	109
<i>I Gede Partha Sindu, Rukmi Sari Hartati, Made Sudarma, Nyoman Gunantara</i>	
Parallel Computing Approach for Preprocessing AIS Data in Transshipment Feature Extraction	115
<i>Widyadi Setiawan, Linawati, I Made Oka Widyantara, Dewa Made Wiharta, Putu Arya Mertasana, Sri Andriati Asri</i>	

Digital Counseling for Cases of Resilience in Students Using the LSTM Model.....	121
<i>Agus Aan Jiwa Permana, Rukmi Sari Hartati, Made Sudarma, I Made Sukarsa, Pande Made Sindu Ardinata, Kadek Suranata</i>	
Open Data Portal Quality (ODPQ) Framework Based Metric for Assessing the Quality of Open Data Portals in Indonesian Local Governments	127
<i>Irmasari Hafidz, Gamal Akbar Adzanni, Nur Aini Rakhmawati</i>	
Developing Character Education Based on Gamification: A Study of Gamification for E-Learning.....	133
<i>Ni Putu Eka Merliana, I Made Oka Widyantara, Ni Made Ary Esta Dewi Wirastuti, Komang Oka Saputra, Djoko Budiyanto Setyohadi, I Gede Agus Krisna Warmayana, I Nyoman Alit Arsana</i>	
Smoothing Convolutional Factorizes Inception V3 Labels and Transformers for Image Feature Extraction into Text Segmentation	139
<i>Komang Ayu Triana Indah, I Ketut Gede Darma Putra, Made Sudarma, Rukmi Sari Hartati</i>	
Biceps Muscle Motor Strength Signal Reading Using AD8226 Sensor	145
<i>I Kadek Bagus Jaya Kusuma, Made Adi Guna Dharma, Dodi Garinto, I Nyoman Satya Kumara</i>	
Optimizing Huge Page Allocation for Efficient Memory Management in Virtualized Systems.....	150
<i>Wu Chia Chuan, Yeap Wei Seng, Lim Chee Khee</i>	
Leveraging Cross-Domain Collaborative Filtering for Improved Movie Recommendations	155
<i>Arif Dwi Laksito, Muhammad Laska Adief Amrullah, Nuruddin Wiranda, Zauvik Rizaldi Maruf, Muhammad Zulfakar, Muhammad Resa Arif Yudianto, Acihmah Sidauruk, Mulia Sulistiyono</i>	
Nighttime Traffic Surveillance Using Glare Reduction and Zero-DCE-Based Low-Light Image Enhancement	161
<i>Duman Care Khrisne, Made Sudarma, Ida Ayu Dwi Giriantari, Dewa Made Wiharta</i>	
Detection and Classification of Cognitive Distortions: A Literature Review.....	166
<i>I Putu Gede Hendra Suputra, Linawati, Nyoman Putra Sastra, Gede Sukadarmika, Ngurah Agus Sanjaya ER, Diana Purwitasari, I Made Agus Setiawan</i>	
4 Section Method for MPPT Optimization in Solar Panel Experiments Under PSC v221023.....	172
<i>Mohammad Jasa Afroni, Efendi S Wirateruna</i>	
Transient Current Maintenance Using Controller Based on Recurrent Neural Network in High Voltage Direct Current Approximation Model.....	178
<i>I Made Ginarsa, I Made Ari Nrartha, Agung Budi Muljono, Sultan, Ni Made Seniari, I Made Budi Suksmadana</i>	

Harnessing Solar Energy: Enhancing Maximum Power Output of Parallel Solar Panels Through External Voltage Analysis	184
<i>I Wayan Sutaya, Ida Ayu Dwi Giriantari, Wayan Gede Ariastina, I Nyoman Satya Kumara</i>	
Applying Stochastic Fractal Search Algorithm for Solving Non-Convex Economic Dispatch Problems	190
<i>Thang Phan Van Hong, Dang Tuan Khanh</i>	
Detection of False Data Injection Attacks in Smart Microgrid Using Deep Learning to Improve Classification Algorithms	196
<i>Hossein Shahinzadeh, Gevork B. Gharehpetian, Wahiba Yaici, Fatemeh Afzoon, Ali Karimi, Farshad Ebrahimi</i>	
Determination of PV Hosting Capacity on the 20 kV Distribution Network Considering Network Configuration	202
<i>Sofyan Hermawan, Lesnanto Multa Putranto, Husni Rois Ali, Fariz Saputra</i>	
Identification of Computation of Solar and Wind Energy Potential for Off-Grid Electric Motorcycle Battery Charging Stations	208
<i>I Wayan Adiyasa, Mohd Azri Hizami Bin Rasid, I Wayan Warsita, Zainal Arifin, Arif Devi Dwipayana, Rai Pramesti Suteja</i>	
Characteristics of Ignition Delay B30 and B100 Biodiesel in Burner System With Variation of Blower Damper Opening	214
<i>Eko Supriyanto, Nur Cahyo, Natalina Damanik, Jayan Sentanuhady, Muhammad Akhsin Muflikhun, Almas Aprilana</i>	
System Design of Microcontroller Based Smart Automatic Transfer Switch of Solar Panel Control.....	218
<i>I Wayan Sukadana, Ida Ayu Dwi Giriantari, Wayan Gede Ariastina, Ida Bagus Alit Swamardika, Agus Putu Abiyasa</i>	
Characteristics of Utilization of Palm Fronds, Oil Palm Stems and Empty Fruit Bunches as Biomass Co-Firing Fuels on Coal-Fired Power Plant	224
<i>Nur Cahyo, Handrea Bernando Tambunan, Eko Hariyostanto, Paryanto, Hariana, Ivan Bagus Novendianto</i>	
Design and Implementation of an IoT-Based Smart Farming System for Sustainable Agriculture: A Case Study on Indoor Farming	229
<i>Muataz Al Hazza, Khaled Hossin, Huwida Nagem, Shahad Alkeebali, Najoua Abida</i>	
Optical FBMC Signals using Frame Repetition for Indoor Wireless Communication System	235
<i>Mohammed S. Bahaielden Bahaielden, Beatriz Ortega, Rafael Perez-Jimenez, Vicenc Almenar</i>	
Author Index	241

Potential of Floating Photovoltaic System at Tanjung 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 Tanjung 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 m² 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, Tanjung, 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 m² 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 literature, 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 Tanjung, Mojokerto, Indonesia. Tanjung Dam is a water reservoir that blocks the small surrounding 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 Tanjung Dam area. The electricity can be exported to the existing grid.

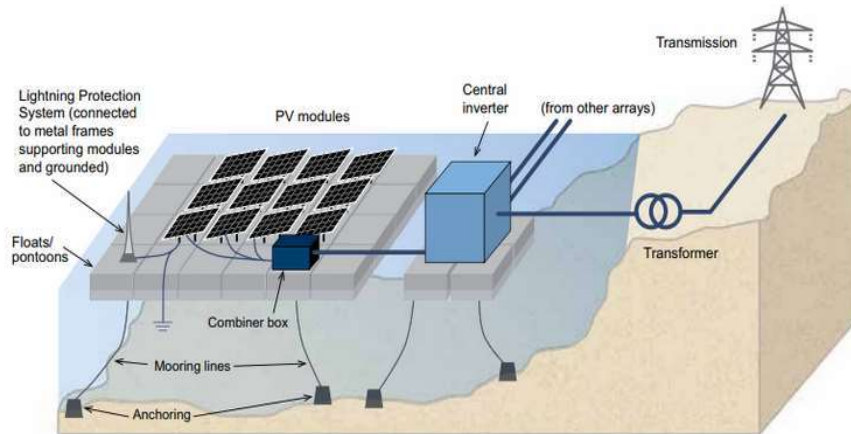


Fig 1. Typical schematic diagram and components of a FPV [6]

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 simulation using SolarGIS Pvplanner software. The software simulation is available online [Reff]. The software simulates the databases of the climate and parameters input numerically. Astronomical position 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 obtain 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 E_o , with the optimum power generation capability P_o , under standart test conditions, in terms of kWp. The unit SEO is therefore kWh/kWp. Mathematically, it can be written as:

$$SEO = \frac{E_o, AC}{P_o, STC} \dots \dots (1)$$



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

Where:

SEO = specific energy output

E_o, AC = energy output at actual condition

P_o, 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 usually 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

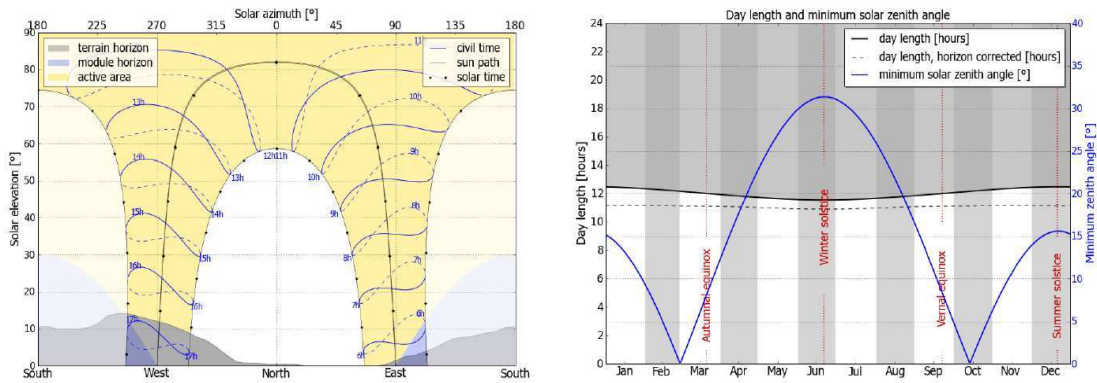


Fig 3. Terrain horizon and day length

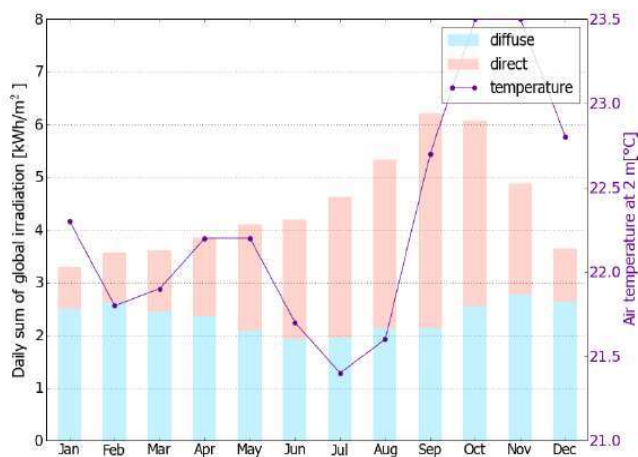


Fig 4. Global solar irradiation

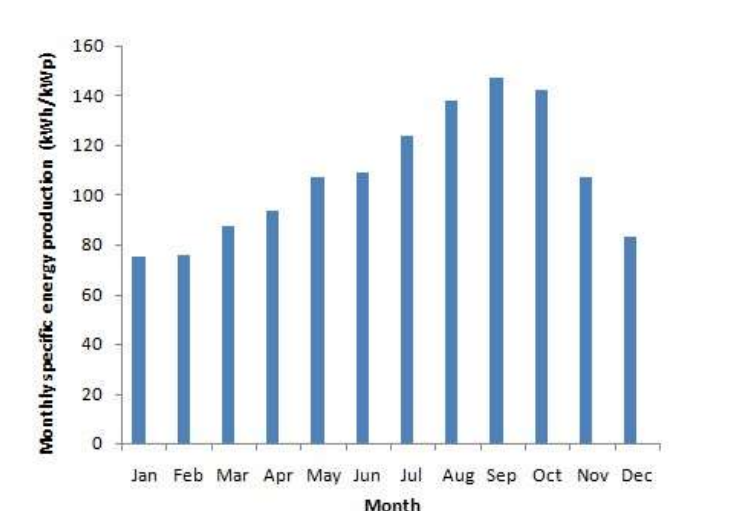


Fig 5. Monthly specific energy output
Global solar irradiation

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 comparison 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 m². According to previous studies [17], [18], a 1kWp with a fixed solar panel system (without any tracking system), would need around 9.2 m² 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 monthly 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. CONCLUSIONS

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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2. LPDP and Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republic of Indonesia Contract No: 159/E4.1/AK.04.RA/2021

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