Assessing the Early Performance of Bifacial Floating PV System: A Comparative Study

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***Abstract*—The increasing need for energy and the limited amount of land have made floating photovoltaic systems gain attention as a possible alternative. Although FPV systems have existed for more than ten years, their extensive use has gained significant traction in recent years. This research investigated the initial performance of a 157.20 kWp bifacial floating photovoltaic system located on Lake B at Universiti Malaysia Pahang Al-Sultan Abdullah, Pekan, Malaysia, utilising 2,574 m² of lake waterbodies. The system was launched during the last week of November 2023. The data collection, which took place from December 2023 to April 2024, shows notable fluctuations in energy production and performance ratio, emphasising the impact of seasonal factors. To get a deeper understanding of the system, a comparative study was performed on real performance data and the results from a PVsyst simulation model. The simulation model, using parameters similar to those of the operational system, projected greater energy yields and performance ratios than the actual observations in the field. The difference between simulation and real data highlights the difficulties in converting theoretical concepts into practical situations. Various factors might impact performance, including lower irradiation, potential-induced deterioration, temperature losses, and inverter inefficiencies. In addition, the simulation and comparison analysis of monofacial and bifacial FPV systems did not reveal any significant benefit of bifacial systems over monofacial systems. The findings of the study highlight the need for rigorous monitoring and assessment of FPV systems to close the disparity between theoretical expectations and actual results.**

Keywords—Floating photovoltaic system, Bifacial PV module, Performance Analysis, PVsyst simulation, Performance ratio

I. Introduction

In light of the growing need for energy and the scarcity of suitable land, floating photovoltaic (FPV) systems are quickly becoming popular. This innovative technique entails installing photovoltaic panels atop buoyant structures secured in bodies of water, such as dams, lakes, and ponds [1]. FPV technology provides a means to alleviate land-use conflicts, especially in densely populated areas with significant agricultural demands [2]. Moreover, FPV systems show potential for enhancing water conservation initiatives. Research has shown that solar panels may significantly decrease evaporation rates in water bodies [3], conserving valuable water resources in dry and semi-arid environments [4].

In addition, the aquatic environment exerts a natural cooling influence on the solar panels. This cooling mechanism has the potential to enhance its effectiveness in comparison to installations on land, particularly in regions with high temperatures [5]. Although FPV technology has existed for more than ten years, its broad acceptance has only occurred recently. The growing interest in FPV systems is driven by many factors, including the decreasing costs of solar modules, floating system design advancements, environmental compatibility recognition, and enhanced performance attained via FPV systems. The use of large-scale FPV systems is increasing significantly. In 2022, the Asia-Pacific market accounted for almost 3 GW of FPV projects, representing more than 90% of the total FPV demand. By 2031, the worldwide FPV market is projected to exceed 6 GW as PV companies face challenges in meeting the increasing demand for solar energy and exploring alternative development approaches [6]. Fig.1 illustrates the countries projected to surpass 500 MW of total permanent FPV installations by 2031.

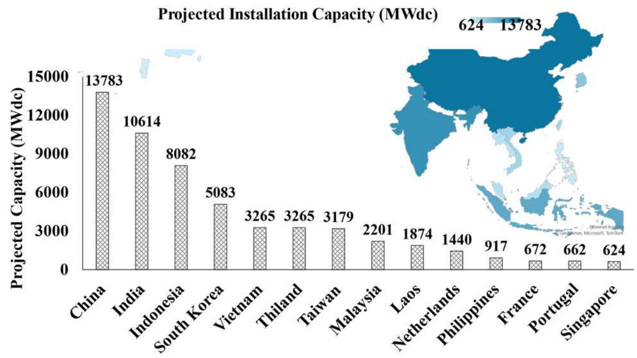

Fig. 1. Countrywise projected cumulative FPV installation capacity (minimum 500 MW DC) by 2031 and map along with legend

An increasing number of studies investigate the performance characteristics of FPV systems. From the mean performance and degradation rate of the practical module, Goswami et al. [7] evaluated the performance characteristics and viability of a 5 MW FPV system intended for West Bengal, India. The PVsyst-based simulation study determined that the power generation capacity of the 5 MW plant is 8604.5 MWh/year and its degradation rate is 1.18%/year. As the work is proposed, however, the actual deterioration and performance of the facility have yet to occur. An exhaustive field test was carried out by Liu et al. [8] at the Singapore Tengeh reservoir FPV plant, unveiling that the water surface atmosphere consistently offers excellent circumstances for photovoltaic deployment, including improved wind circulation and lower ambient temperature. However, it is accompanied by the disadvantages of reduced albedo and increased humidity. According to the study, the FPV system exhibits a performance ratio (PR) varying from 80% to barely surpassing 90%, which is approximately 10% greater than the rooftop system. Farrar et al. [4] compared floating solar

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