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Floating Solar Panel on Agriculture Pond

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Abstract*: Floating solar power plants present an innovative solution for farmers facing constraints of limited land and water resources. This study assesses the feasibility of on-grid floating solar power plants for farmers, offering a sustainable and cost-effective energy source while conserving land area and improving water quality. Through technical, economic, and environmental analyses, this study demonstrates the viability of on-grid floating solar power plants, highlighting their potential to enhance farmers' livelihoods and contribute to rural sustainable development. Additionally, this paper introduces a novel approach by estimating the technical potential of floating photovoltaic systems (FPV) at the province/municipality level, focusing on water irrigation ponds, thus offering insights for localized implementation strategies.*

Keywords: Solar, PowerPlant, FPV, Ponds

I. INTRODUCTION

In India, where solar energy abounds, the transition to renewable energy sources, particularly solar, is imperative to meet the rising electricity demand amid diminishing fossil fuel reserves. However, land scarcity poses a significant challenge to large-scale solar installations. Floating solar power presents an innovative solution to this challenge, particularly beneficial for farmers who often have access to water bodies on their land. By integrating floating solar power plants into their operations, farmers can not only meet their energy needs sustainably but also contribute excess energy to the grid, potentially generating additional revenue streams.Despite global efforts to transition to renewable energy sources, progress has been slow, necessitating the integration of non-techno-economic factors into energy planning processes. Solar photovoltaic (PV) technology emerges as a promising renewable energy option, expected to dominate the energy landscape by 2050. However, concerns regarding environmental impacts and land use conflicts associated with ground-mounted PV installations persist. Floating PV systems offer a viable alternative, eliminating land acquisition costs, reducing water evaporation, mitigating algae growth, and potentially increasing electricity generation efficiency due to cooling effects. Additionally, floating PV projects can address climate change impacts on water bodies, promote water-food-energy nexus synergies, and garner social support. ## IntroductionIn India, the abundance of solar energy presents a compelling opportunity to transition towards sustainable energy sources amid increasing electricity demand and dwindling fossil fuel reserves. Solar energy, harnessed through photovoltaic (PV) technology, offers a clean, renewable, and readily available energy source, making it an attractive option for meeting the country's growing energy needs. However, the challenge of land availability poses a significant constraint to the large-scale deployment of ground-mounted solar installations.In this context, floating solar power plants emerge as an innovative solution to address the dual challenges of land scarcity and energy demand. By utilizing water bodies such as lakes, ponds, and reservoirs for PV installations, floating solar power plants offer a unique opportunity to maximize solar energy generation without occupying valuable land resources. This approach not only leverages underutilized water bodies but also presents additional benefits such as water conservation, algae mitigation, and potential improvements in water quality.

Moreover, the adoption of floating solar power plants holds particular promise for farmers, who often face land and water resource constraints. By integrating floating solar installations into their operations, farmers can not only meet their energy needs sustainably but also potentially generate surplus energy for sale to the grid, thereby diversifying their income streams. This concept of on-grid floating solar power plants not only addresses energy security concerns but also contributes to rural electrification efforts and supports the socio-economic development of farming communities. Despite the global momentum towards renewable energy adoption, challenges remain in achieving rapid and widespread deployment, necessitating comprehensive and holistic approaches to energy planning. In this regard, the integration of non-techno-economic considerations, including environmental sustainability and social equity, is crucial to ensure the long-term viability and acceptance of renewable energy solutions.This paper aims to explore the feasibility of on-grid floating solar power plants for farmers in Maharashtra, India. Through a multi-dimensional analysis encompassing technical, economic, and environmental perspectives, this study seeks to assess the viability of floating PV systems in addressing the energy needs of farmers while promoting sustainable land and water management practices. Additionally, by estimating the technical potential of floating PV systems at the provincial/municipal level, this research contributes novel insights into localized implementation strategies for maximizing the benefits of floating solar technology.

II. LITERATURE REVIEW

Floating Photovoltaic Systems: A Sustainable Alternative

Floating photovoltaic (FPV) systems have gained increasing attention as a sustainable alternative to traditional ground-mounted solar installations. Notably, FPV systems offer several advantages, including the efficient utilization of water bodies, reduced land requirements, and potential enhancements in electricity generation efficiency due to the cooling effect of water. According to Ho et al. (2020), FPV systems have demonstrated higher electricity generation efficiency compared to ground-mounted PV systems, attributed to the cooling effects of water, thereby enhancing overall system performance.

Environmental Benefits of Floating PV Systems

In addition to their technical advantages, floating PV systems offer significant environmental benefits. By covering water surfaces, FPV systems reduce water evaporation rates, mitigate algae growth, and potentially improve water quality. Studies by Bergmann et al. (2018) have highlighted the role of floating solar installations in reducing water evaporation, thereby conserving valuable water resources, particularly in regions prone to water scarcity.

Economic Viability and Market Trends

The economic viability of FPV systems has been demonstrated in various studies, with favorable returns on investment attributed to cost savings from reduced land acquisition, potential revenue from surplus energy sales, and ancillary benefits such as water conservation. According to a report by the World Bank (2019), FPV systems have emerged as a cost-competitive alternative to ground-mounted PV installations, with installation costs declining steadily and market demand increasing globally.

Policy and Regulatory Frameworks

Policy and regulatory frameworks play a crucial role in facilitating the deployment of FPV systems. In countries like Japan and South Korea, supportive policies and incentives, such as feed-in tariffs and tax incentives, have spurred the growth of floating solar installations (Tran et al., 2020). However, challenges remain in navigating regulatory hurdles and addressing concerns related to environmental impact assessments and land/water rights.

Case Studies and Practical Applications

Several case studies and pilot projects have demonstrated the feasibility and effectiveness of FPV systems in various contexts. For instance, the Banasura Sagar Dam floating solar project in India has showcased the technical feasibility and economic viability of FPV systems in harnessing solar energy from water bodies (Nagendra et al., 2021). Similarly, the Yamakura Dam floating solar project in Japan has illustrated the scalability and environmental benefits of FPV systems in mitigating water evaporation and algae growth (Tran et al., 2020).

Research Gap and Novelty

While existing literature has explored the technical, economic, and environmental aspects of FPV systems, there remains a research gap in assessing the localized potential of floating solar installations at the provincial/municipal level, particularly focusing on water irrigation ponds. This study seeks to address this gap by providing novel insights into the technical feasibility and economic viability of on-grid floating solar power plants for farmers in Maharashtra, India, with a specific focus on water irrigation ponds as potential sites for FPV installations. By estimating the FPV

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technical potential at the provincial/municipal level, this research aims to contribute to localized implementation strategies for maximizing the benefits of floating solar technology in rural areas.

III. METHODOLOGY

This study employs a multi-dimensional approach to assess the feasibility of on-grid floating solar power plants for farmers in Maharashtra, India. Technical feasibility is evaluated based on site suitability, solar irradiance, water body characteristics, and floating platform design. Economic viability is analyzed through cost-benefit assessments, considering installation costs, electricity generation potential, revenue generation from surplus energy sales, and potential savings from water conservation. Environmental impact assessments encompass considerations of water quality improvement, biodiversity preservation, and greenhouse gas emission reductions

3.1 WORKING

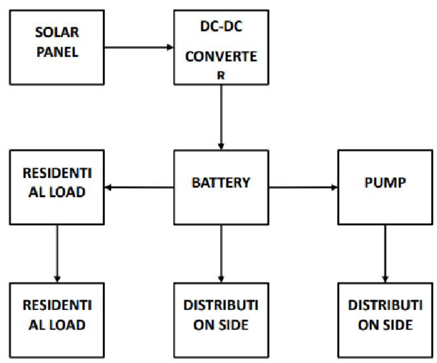

Figure 1 Block diagram

The block diagram you provided illustrates the system of a floating solar panel on agricultural ponds. Here's a brief explanation of the components and their connections:

- Solar Panel: This is the main component that captures sunlight and converts it into electricity.
- DC-DC Converter: The electricity generated by the solar panel is directed to this component, which adjusts the voltage levels for optimal use or storage.
- Battery: The converter can direct the electricity to a battery for storage, ensuring that power is available even when the sun isn't shining.
- Pump: The electricity can also be used to power a pump, likely for irrigation purposes in the context of an agricultural pond.
- Residential Load: The system can provide electricity directly to residential loads, powering household appliances and systems.
- Distribution Side: This could represent the broader electrical grid, to which excess power can be distributed.

The arrows indicate the direction of energy flow or connection between these components. The layout suggests that energy captured by the solar panel is converted and can be stored in a battery or used directly to power residential loads or a pump. This system allows for efficient use of solar energy and could be particularly beneficial in agricultural settings. It's a great example of sustainable and renewable energy utilization.

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IV. RESULTS AND DISCUSSION

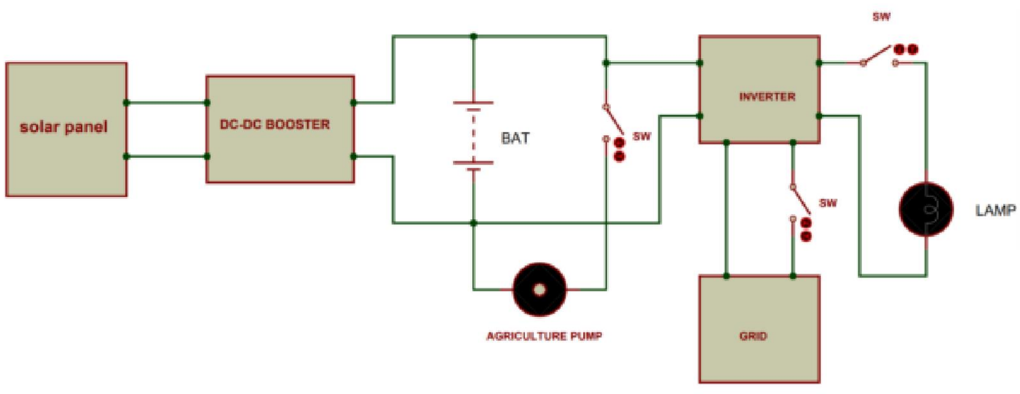

Figure 2 Circuit Diagram

The diagram show in figure 2 depicts a basic solar power system with battery storage, designed to power a lamp and potentially an agricultural pump . The system consists of the following components:

- Solar panel: This is a photovoltaic (PV) panel that converts sunlight into direct current (DC) electricity . The solar panel in the diagram is labeled with a positive (+) and negative (-) terminal, indicating the flow of DC electricity.
- DC-DC booster: This electronic device increases the voltage of the DC output from the solar panel . The booster increases the voltage to a level suitable for charging the battery and powering the lamp. The DC-DC booster in the diagram isn't labeled with positive and negative terminals, but they would typically be present.
- Battery: This rechargeable battery stores energy from the solar panel when sunlight is available. The battery provides power to the lamp at night or during cloudy periods . The battery in the diagram is labeled with positive (+) and negative (-) terminals.
- Inverter (not shown but labeled): An inverter is a device that converts DC electricity from the battery to AC electricity . While the diagram shows the inverter and mentions it in the title, it is not depicted in the circuit itself. An AC inverter would be necessary to power an agricultural pump, as agricultural pumps typically run on AC electricity.
- Lamp: This is a device that converts electrical energy into light . The lamp in the diagram is labeled with a switch (SW) and is connected to the positive and negative terminals of the battery.
- Agricultural pump :This is a pump powered by an electric motor that can be used for irrigation . The agricultural pump is mentioned in the title of the diagram but not depicted in the circuit itself. An AC inverter would be required to run an agricultural pump, as agricultural pumps typically use AC electricity.

Here is how the solar power system with battery storage works:

- Sunlight strikes the solar panel, generating DC electricity.
- The DC electricity flows from the solar panel to the DC-DC booster.
- The DC-DC booster increases the voltage of the DC electricity.
- The boosted DC electricity flows to the battery, charging it.
- When the lamp is turned on, DC electricity flows from the battery to the lamp, lighting it.

The purpose of the DC-DC booster in this system is to increase the voltage of the DC electricity from the solar panel to a level that is suitable for charging the battery and powering the lamp. Solar panels typically produce a voltage that is too low to directly charge a battery or power a lamp. By increasing the voltage, the DC-DC booster makes the solar power system more efficient.

Here are some additional details that could be included in a research paper about this solar power system with battery storage:

- The specific voltage and wattage of the solar panel, DC-DC booster, battery, and lamp.

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- The type of battery used in the system (e.g., lead-acid, lithium-ion).
- The capacity of the battery (e.g., amp-hours).
- The amount of time it takes for the solar panel to charge the battery.
- The length of time the lamp can be powered by the battery on a single charge.

V. CONCLUSION

On-grid floating solar power plants offer a promising solution to address energy challenges faced by farmers in Maharashtra, India. By leveraging existing water bodies, farmers can harness solar energy sustainably, contributing to rural electrification efforts while preserving land and water resources. The findings of this study underscore the importance of integrating non-techno-economic considerations into energy planning processes and highlight the potential of floating PV systems to drive sustainable development at the local level. Moving forward, policymakers, researchers, and stakeholders must collaborate to facilitate the widespread adoption of floating solar power technology, realizing its socio-economic and environmental benefits for farming communities and beyond.

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