Evaporation Reduction by Solar Photovoltaic (SPV) System: A Review

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Abstract

Many methods have been tested and developed worldwide to protect water from the evaporation process. This paper presents a recent overview of published research on reducing water evaporation from solar PV systems, with a focus on renewable energy sources. The main features, advantages and disadvantages of this method involved in this paper. Another fact is that energy crises have increased over the years due to the growing world population and the expansion of ecumenical industries, particularly for food and necessities. Most of the energy is consumed in power generation, industries and factories, transportation, and the municipal sector. In addition, to implement our temporary mandate, we rely largely on energy derived from fossil oil, gas, and coal. In developing countries like India, more than 70 percent of the population lives in rural areas, where more than 85 percent of the energy consumed comes from non-conventional sources, primarily fuelwood. This means that these PV systems can be used to generate electricity as needed.

Key Words- Evaporation, SPV System, renewable energy sources, electricity, solar panel

Introduction

Evaporation in which liquid changes to gas without becoming hot enough to boil. It occurs when individual liquid particles at exposed surface of liquid absorb enough energy to overcome force of attraction with other liquid particles. If surface particles are moving in right direction they will pull away from liquid and move into air. Control of evaporation from water bodies has been one of main planks of water conservation. Several factors affect the evaporation of water from water Temperature-Higher the temperature greater the rate of evaporation. When temperature of liquid increases, the kinetic energy of individual molecules also increases. Thus, energy makes it easier for liquid molecules to overcome the intermolecular forces of attraction and escape into atmosphere as a gas. Using solar panels to reduce water surface evaporation is an interesting concept that has been explored in various forms. The basic idea is to cover a portion of the water surface with solar panels to create shade and decrease direct exposure to sunlight, thereby reducing evaporation. Here are some key points to consider:

Design and Installation: The solar panels would need to be installed in a way that provides shade to the water surface without obstructing the entire area. This requires careful design and placement to maximize the coverage while allowing access to the water.

Benefits: This approach can help reduce water loss due to evaporation, which is particularly relevant in arid regions or areas facing water scarcity. Reduced evaporation can lead to water conservation, potentially benefiting agriculture, reservoirs, and other water-dependent sectors.

Challenges: Cost: Setting up solar panels can be expensive. While they could provide dual benefits of reducing evaporation and generating electricity, the costs need to be justified against the benefits.

Efficiency: The effectiveness of this method would depend on factors such as the climate, water depth, and local conditions. It might not completely eliminate evaporation but could significantly reduce it.

Combined Systems: Some projects have explored combining floating solar panels with other technologies, such as membranes or coatings, to further reduce evaporation. These additional components can create a barrier between the water surface and the atmosphere, slowing down the evaporation process.

Studies

Covering the canals with a solar photovoltaics system (SPVS) is expected to significantly reduce evaporation. However, Evaporation rates from flowing canals can take values as high as 5–20 mm/day (Kougias et al., 2016).

India has been a pioneer country in the field of canal-top solar projects. In February 2014 was inaugurated a 10 MWp project of this kind in India with a total cost of $18.3 billion. The system lays over 3.6 km of the Narmada irrigation canal in Gujarat's Vadodara city in western India, consists of 33,816 solar panels as shown in Fig. 4. Owing to using this system, 6 acres of land and about 9 million liters of water are saved every year. Natural cooling of SPVS is an additional advantage of using solar panels over irrigation canals, leading to increase the efficiency of the solar panels by 7%, compared to ground SPVS (A. Keya., 2015). This research analysed the possibility of alternative choices for SPVS installations to be implemented on the downstream face of dams and over irrigation canals in the Mediterranean islands because they have limited water resources and a wealth of solar potential. 15 canals were selected: 11 in Sardinia (Italy), 3 in Sicily (Italy) and 1 in Cyprus. It was generally expected 3000 m3 of water savings per MWp of SPVS. This research concluded that the SPVS has the potential to secure ≈170,000 m^3 of water from canals, annually. However, improving the aesthetics of the regions around the canals is an additional advantage for using of SPVS over canals (Kougias et al., 2016).

Energy crises have worsened over the years due to growing world population and the expansion of ecumenical industries, particularly for food and necessities. Most of the energy is consumed in power generation, industries and factories, transportation and the municipal sector. In addition, to implement our temporary mandate, we rely largely on energy derived from fossil oil, gas and coal. In developing countries like India, more than 70 percent of the population lives in rural areas, where more than 85 percent of the energy consumed comes from non-conventional sources, primarily fuelwood. The rising cost of conventional fuel in urban areas requires research into other energy sources. Solar energy offers an alternative source of energy to replace fossil fuels in rural and urban India. We can harvest solar energy from the sun; The sun is an important source of solar energy (Gaikwad et al., 2016).

Solar energy is one of the most productive renewable energy sources of the future. This solar energy can be obtained by a PV system. There are many methods used for PV installation, e.g. B. a PV system on a roof or a PV system on a dam. Floating PV systems, duct-top PV systems, etc. In duct-top systems, PV modules are placed over the water channel, saving installation space and reducing evaporative losses. The performance of a PV system mainly depends on the light intensity, so the power output can be increased by a concentrating PV system. The use of a concentrated PV system can reduce the investment costs per kWh. In this paper, channel-top PV systems with spaced-array reflectors are studied. The expected benefit of such a system is that evaporative loss can be further reduced and an additional cooling system may not be required. In order to ensure uniform light availability and to avoid

shading on the panels, the tilt angle of the panel, the distance between the arrays and the alignment of the reflectors are optimally calculated (Rani et al.,2016).

Energy and the availability of good quality water are essential for human well-being. Therefore, it is very important to study the parameters that would affect the water quality in order to develop remedial measures in case the water quality would be compromised or adversely affected. In addition, it is very important to always look for new sources of energy, especially if they are renewable. This research study is concerned with the study of solar ducts and their impact on evaporation and water quality variables of ducts covered with solar panels, as well as the impact on electricity production. Both a mathematical model and an optimization study were conducted to determine the aforementioned effects, thereby determining the most favorable percentage of coverage of the case study channel area that would result in minimum evaporation volumes, maximum performance, and still maintain and meet water quality variable standards the covered waterway. Water quality variables studied include dissolved oxygen concentration, algae, nutrients and water pH. It has been found that between 33% and 50% of channel coverage is optimal (Sherine et al.,2020).

The energy disaster has increased over the decades due to population growth, factories and industry. Most of the energy comes from thermal power plants. Renewable energy sources are the best or most desirable energy solution for fossil fuels. There are different types of renewable energy sources, but solar energy plays an important role among renewable energy sources due to its availability, clean, safe and pollution-free nature. The construction of a solar power system requires very large areas. Utilizing the solar power plant system at the top of the canal reduces the need for large land area and decreases water evaporation from sunlight. The cost of solar energy is falling very quickly. Solar thermal electricity (STE) and solar photovoltaic electricity (SPVE) are becoming competitive with conventional energy. To overcome these problems, the innovative idea of installing a solar power plant system on channel tops using a space between the solar panels is employed. This reduces evaporation of water from the spacing between the arrays and increases radiation on the solar panel, so the power output of the system also increases. This article mainly pays attention to the solar power system with and without reflectors on ducts, compares the efficiency and cost of both systems, and suggests which system is the least suitable for installing solar power plants (Sairam et al., 2020).

The potential impact on water quality and quantifies the benefit of the low-carbon energy source of floating solar panels in reducing evaporation when deployed on an open body of water, such as an agricultural irrigation pond in semi-arid regions. By using agricultural ponds for low-carbon energy conversion and conserving valuable water by reducing evaporation, the highly vulnerable agricultural sector will be strengthened. A pilot plant will be prepared, key water quality parameters will be monitored, and evaporation rates in a PV-covered pond will be compared to those of an adjacent open water pond, which will serve as a control. Several panel inclination angles were tested. The results showed no negative impact on water quality; on the contrary, there are indications of an improvement in nitrate and chlorophyll concentrations. In addition, a reduction in evaporation of about 60% was observed; Power generation from floating solar panels, on the other hand, was statistically comparable to power generation from ground-mounted solar panels (Qasem 2021).

By 2050, electricity consumption will more than triple worldwide. Despite its enormous potential as an environmentally friendly power generation technology, solar energy accounts for only a small part of global demand. One of the topics is the sustainable use of land resources. Power engineering is a popular engineering discipline concerned with the study of conventional and unconventional sources of energy in today's world. The aim of the work is to use conventional energy sources to generate non-traditional

energy sources and focus on the study of floating solar collectors using the solar hybrid power plant. In addition, the focus is on the use of photovoltaic solar panels, which use hydroelectricity all year round, if it is a non-conventional energy source, and we can use it all year round using hydroelectricity, which does not have one -conventional energy source features. Solar energy is plentiful (Singh et al., 2023).

Generating solar energy from wasteland or rooftops is a critical issue in the smart city program, a need that is difficult to meet in metropolitan and other large cities. Given the country's extensive irrigation canal network, the idea of installing a solar PV system on the canal top was taken up. In the first ten years, the power output of ground-mounted PV modules typically decreases by a flat 1%. In contrast, a recent study by the Gujarat Energy Research and Management Institute (GERMI) found that steady power generation can be achieved even after three and a half years of continuous operation and solar exposure. This is a major achievement that will extend the lifespan of the solar panels mounted on the channel to over 25 years. The canal apex serves as the best management model for solar powered water pumps and village electrification at the community level. The solar PV project on the canal is vital to the smart city initiative and national solar mission (Hanaji., 2022).

Table: FPV Advantages and drawbacks compared to ground-mounted PV

FPV advantages	**FPV challenges**
Higher conversion efficiencies due to the cooling nature of water and in many cases the absence of dust.	Higher initial investment, operation & maintenance costs.
FPV installations can reduce surface water evaporation. Importance in arid regions.	Uncertainty of long-term environmental impacts.
FPV requires no land, so does not compete with other land-users such as agriculture, mining, or tourism.	Metallic structures are more prone to corrosion, hence FPV has a shorter lifetime than ground-mounted PV.
FPV limits algae growth thus improving water quality.	Lack of separate regulations for permitting and licensing FPV projects.
Risk of theft and vandalism is reduced.	

(Reindl et al (2020), Friel et al (2019), Sahu et al (2016))

Conclusion

The solution of installing solar panels on irrigation canals or open water surfaces has shown that it can bring several advantages, documented in the projects and research carried out worldwide: The advantages that allow to reduce the growing land consumption for the installation - ground solar panels. In all countries, the current solar parks bring important benefits in terms of renewable energy production, while creating problems for agriculture, forests, landscapes, and local community activities. By reducing the water temperature, the panels installed above the channels are more efficient than those installed on the ground. The energy generated from the solar channel can provide electricity to farmers during the energy-intensive irrigation season. Off-season electricity can be fed into the national grid, sold to distribution companies, or used by the sewer authority. The solar panels provide shade for the water flowing into irrigation canals. They prevent evaporation from the channels that run through an arid and sun-drenched region. Covering the canal saves water, creates a more efficient irrigation system, and improves water security for farming communities that rely on the canal. Another advantage of the panels is the containment of algae blooms in the channels. Algae growth can clog water pumps and cause toxins. The solar power plant on the canal is a novel concept that makes optimal use of the land area while saving water. For smart village, smart city and irrigation projects, it offers a better management approach. It can

also be built within the framework of a public-private partnership (PPP). Projects at the top of the channel are expected to achieve a greater share of national solar targets as costs come down. Solar energy projects in India could be implemented faster and cheaper if large-scale solar farms were built on the canals.

References

A. Keya, (2015) Solar Plant a top Irrigation Canal Impresses UN Chief. *India Climate Dialogue*

Kougias I., K. Bódis, A. Jäger-Waldau, M. Moner-Girona, F. Monforti-Ferrario, (2016) *J. Sol. Ener. (SEJ)* **136**, 174-182.

Rani C. and Joffie Jacob (2016) Canal top solar energy harvesting using reflector, GRD *Journals- Global Research and Development Journal for Engineering*: **1(8).**

Sahu A., N. Yadav, and K. Sudhakar (2016) Floating photovoltaic power plant: A review, Renewable *and Sustainable Energy Reviews*, **66**. Elsevier Ltd, pp. 815–824.

Gaikwad O. D., and U. L. Deshpande (2017) Evaporation control using floating pv system and canal roof top solar. *system International Research Journal of Engineering and Technology (IRJET)* **04 (04)** 214-216.

Friel D., M. Whittaker, T. Doran, W.J. Howlin (2019) A review of floating photovoltaic design concepts and installed variations 4th International Conference on Offshore Renewable Energy, *ASRANet Ltd*.

Reindl T. et al., (2020) Where Sun Meets Water FLOATING SOLAR MARKET REPORT," 2019. https://esmap.org/where_sun_meets_water_floating_solar_market_report (accessed Apr. 10, 2020)

Sherine El B. and Mai Al Sadeq (2020) Effect of Solar Canals on Evaporation, Water Quality, and Power Production: An Optimization Study. *Water,* **12,** 2103.

Sairam M.N. and A. Aravindhan (2020) Canal top solar panels: A unique nexus of energy, water, and land Author links open overlay panel. *Materialstoday proceedings*, **33, (1),** 705-710.

Qasem A. (2021) Floating PV; an assessment of water quality and evaporation reduction in semi-arid regions. *International Journal of Low-Carbon Technologies*, Volume **16(3),** September 2021, 732–739.

Hanaji Asha (2022) The Concept of Canal Top Solar Power Plant Miss International Journal of Research Publication and Reviews, **3(3)** 933-935.

Singh Vikram and Harpreet Kaur Channi (2023) Analysis of Floating Solar Panels for Solar Pumping Irrigation System, ICASF-2022 IOP Conf. Series: *Earth and Environmental Science* 1110 (2023) 012074.