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Floating photovoltaic plants and wastewater basins: an Australian project

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Abstract

Floating photovoltaic is a new design solution for photovoltaic (PV) power plants; Floating PV systems (FPVSs) are normally installed on water bodies such as natural lakes or dams reservoirs, and offshore solutions are also investigated. Such technology has attracted increased worldwide attention since 2007 and medium and large FPVSs have already been deployed in several countries, such as Japan, South Korea, India and USA. The cost effectiveness of FPVS increases dramatically if the floating structure performs also other tasks, for instance the reduction of water evaporation.
In this context, the possibility to integrate PV plants with the existing basins for wastewater treatment is explored; a compact FPVS without tracking with optimal orientation and distance among rows is suggested as the most simple and economic design solution. Some test cases in South Australia are suggested and analysed.

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Keywords: photovoltaic system; floating system; water basin; evaporation

1. Introduction

The use of land by photovoltaic (PV) plants can be partially or totally avoided by implementing an emergent solar technology known as floating PV, which tries to break the paradigm that mounting solar panels on water surfaces is an expensive and complicated process (as reported by IEA annual report in 2014). This technology is now being

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deployed in projects across the world [1]. FPVSs are generally comprised of a racking assembly mounted on top of floating structures (FS), such as rafts or pontoons, which are installed on enclosed water bodies such as reservoirs, ponds and small lakes. Due the novelty of these PV solutions, most systems are proprietary and of small-medium size. However, many different models and systems of varying scales (up to megawatt scale) have been created with even bigger plans for the future. In reference [2] a review of the main floating PV plants in the period 2007-2013 is reported as well as a general analysis of the main technologies: submerged systems, thin film floating systems and floating systems either fixed or with tracking. Reference [3] further develops this analysis extending it to 2016. In the past 2 years about 100 MW were installed around the world. The authors forecast a very large expansion of the sector and maintain that India's ambitious target of 100 GW within 2022 will get a wide contribution from floating plants.

In the last ten years, the floating photovoltaic systems (FPVSs) installed on water bodies such as natural lakes or dams reservoirs, have been attracting more and more worldwide attention and have already been deployed in several countries, including Japan, South Korea and USA. The floating PV plant is an emerging technology proposed by the authors almost 10 ago and several studies confirm their quick growing [2].

Several technical advantages that have been attributed in literature to FPVSs are listed and discussed in [4] from a practical point of view, specifically:

(1) the evaporative cooling of PV modules and cables caused by the water body increases the efficiency of the system;
(2) FS reduces the evaporation off the free surface of the water, conserving the volume of stored water;
(3) FS reduces algae growth;
(4) FS reduces the formation of waves and, thus, the erosion of the banks of the reservoir;
(5) the fact that the floating system does not use a land area is a great economic advantage;
(6) the reflectivity (albedo) of the water increases the incidence of radiation in the PV array and, therefore, its energy generation.

In case of installation of FPVS on an existing generation structure (e.g. hydroelectric power plant) or supplied structure (e.g. pumping station) the following advantages can be listed:

(7) a floating PV system installed on the reservoir of a hydroelectric power plant saves water in that reservoir, replacing part of its generation;
(8) a floating PV system installed on the reservoir of an already electrically connected structure does not require investment in transmission infrastructure, since the existing infrastructure can be shared.

In this paper, we want to analyze in detail the second point, that is the impact of FS on evaporation rate in the water basin. Two main factors together contribute to the reduction of water evaporation: 1) the shading provided by the floating structure reduces the incidence of solar radiation on water, and therefore its temperature, 2) the FS partially covers the free surface of the water and so it reduces the effect of the wind on this surface.

How much water would be lost without the FPVS depends on the place and local climate and has to be carefully calculated to evaluate this critical advantage.

On the other hand, it should also be mentioned that this effect is physically conflicting with the previous one, that is, the less evaporation in the reservoir, the lower the evaporative cooling caused by the water body and the lower the efficiency increase of the photovoltaic array.

In this report we explore how the coupling of FPVSs to the standard wastewater treatment basins is a very interesting integration, with environmental advantages and economic gain for both sectors: energy production and water saving.

We apply this study to Australia since, as evident from map in Figure 1 and in Figure 2, it is a continent where an interesting level of solar radiation is coupled to a rather arid climate so that the opportunity to save water is an important target.

Specifically, in Fig. 1 the radiation map for the full continent is shown. Very interesting values are reached in most of the inhabited areas except in the very deep South. Data are taken from the Government Bureau of meteorology [5].

The same Bureau also supplies a map of the evaporation rate showing very large losses of water from 2 to 4 meters, which implies that the basin depth is reduced by this amount in one year (see Figure 2).