Floating Photovoltaics: A New Way to Attenuate Climate Change Effects on Lakes and Reservoirs

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Abstract A big problem to be addressed is the effects that climate change produces, specifically on lakes and water reservoirs. A possible solution to this is using a relatively new technology called Floating Photovoltaics Systems. These systems have the capability to generate electricity from solar energy while sheltering the water they float on from the solar rays. This reduces water evaporation and algae growth, improves the water quality, and keeps the system passively cooled. This paper focuses on showing that technologies such as these are the future to take action against climate change effects on lakes and water reservoirs, and FPV is the main one to focus on at the moment, as it is the most effective one.

***Index Terms*— climate change, environmental impact, floating photovoltaics, renewable energy, solar energy, water bodies.**

I. Introduction

In the last years, the environment has been heavily affected by the effects of climate change, with very few solutions being developed to mitigate the problem. There is an urgent need for action, with renewable electricity production needing to grow faster in order to limit global heating. This is where floating photovoltaics (FPV from here on) come into play. This type of technology could help mitigate the negative effects that global warming has on bodies of water.

The United Nations' Sustainable Development Goals (SDGs) Report [1], which calls for all countries to promote prosperity while protecting the planet, includes a goal about climate change effects mitigation by means of clean energy generation. For this reason, this paper delves into a possible solution to this serious issue. Therefore, the purpose of this paper is to describe the floating photovoltaic systems and explain the way they can help mitigate climate change impact on lakes and reservoirs.

To achieve this, this paper describes the functionality and features of the FPV systems. In the next section, their possible uses are explained, including their potential locations and conditions in which they can be used as well as their cost of installation. After that, the effects they have on the environment are discussed. Finally, some examples of already existing installations are provided.

II. Floating Solar Panels

A. Features

FPVs are systems constituted by various devices and parts. A floating photovoltaic plant consists of a floating system, which is designed to float on the water and supports a heavy load that can contain several panels; a mooring system, which ensures and prevents the free movement of the floating structure in the water; a photovoltaic panel, which generally consists of an array of photovoltaic cells (photovoltaic generation equipment); a solar inverter and, sometimes, a battery and/or a solar tracker, which is a mechanical device that orients the modules in the direction of the sun, and interconnection cabling and submarine cables, which transfer the energy generated from the bodies of water to the substation. Due to their outdoor use, the cables are designed to withstand extreme conditions [2].

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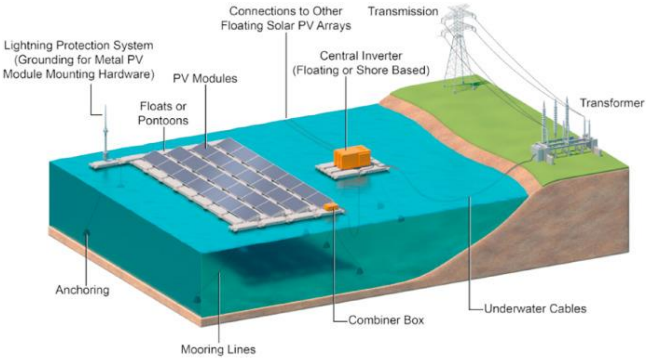

Fig. 1 Floating Photovoltaic Plant

B. *Functionality*

A photovoltaic cell is a semiconductor which converts solar radiation into electricity. This semiconductor consists of two types of materials: P and N (Positive and Negative). When the cell absorbs photons from sunlight, the electrons collide and are released from the silicon atoms (N-type Material), which are extracted by a grid of metallic conductors, which produce a constant flow of electrical current [3].

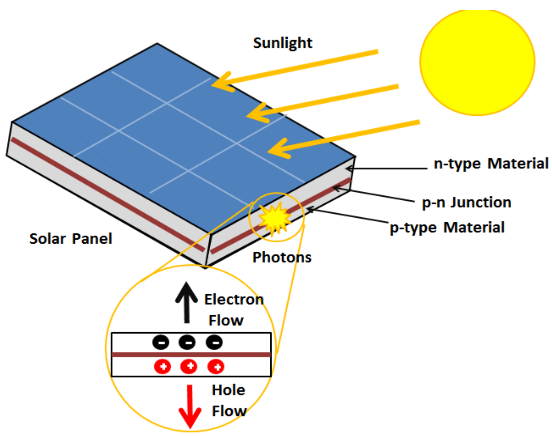

Fig. 2 Internal Reaction in Photovoltaic Cells

A photovoltaic panel is made up of several photovoltaic cells connected in series. From these panels a direct current is obtained. This current goes to the inverter and is transformed into alternating current for use and distribution.

III. Uses

A. *Locations*

The floating PV are systems that float on water surfaces such as water reservoirs and quarry lakes. There are certain advantages to these locations. These systems are cheaper to install as there is no need to pay for land. That is, water bodies have a few regulations and rules to comply with. As well as this, these floating PV systems are non-obstructive, as these locations are mostly hidden from public view. These systems also have the capacity to be passively cooled by the water they are installed on [4], which add another benefit to these areas.

B. *Conditions*

FPVs are designed to withstand extreme conditions such as storms and typhoons. They can be installed on any water body that provides enough sunlight; however, saltwater bodies and high waves could cause damage over time. If these systems are installed on water bodies that are known for large tidal movements and high currents, they must be equipped with mooring lines and anchors capable of withstanding such conditions [2].

C. *Costs*

The capital costs of FPV power are still slightly higher than ground-mounted PV power due to the need to install floats, moorings, and stronger electrical components. However, floating structures costs are decreasing over time due to better economies of scale [5].

A great advantage of using FPV is the reduction in the costs of land acquisition and site preparation. It is estimated that, compared to traditional systems, FPV systems could reduce energy cost by 1.3% –1.7% due to avoided land costs [6].

Another factor that affects the cost of FPV is the location of the project since the costs of the installation of the moorings and maintenance depend on the depth of the body of water. Nonetheless, if an FPV is installed next to a hydroelectric power plant, the costs in the power transmission system could be lowered.

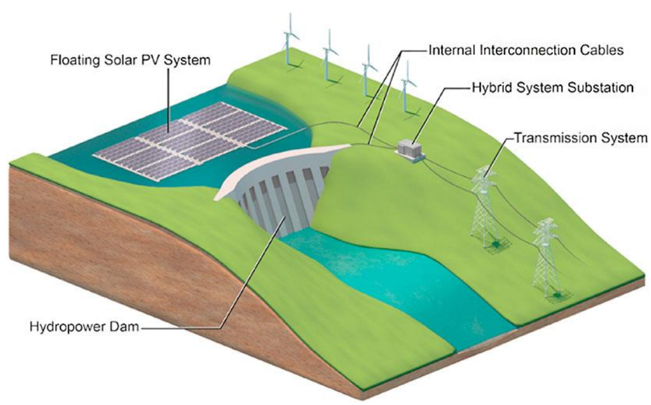

Fig. 3 Floating Photovoltaic Plant installed on a Dam

IV. Environmental Impact

The sun offers virtually limitless energy while coming with very few drawbacks in terms of environmental impact and renewability. Floating solar panels, offer multiple benefits on top of the ones regular solar panels provide.
Some benefits include:

• reducing evaporation from water reservoirs, as the solar panels provide shade and limit the evaporative effects of wind.
• self-cooling capabilities, which eliminates the need of extra electricity used for regular cooling.
• improving water quality, by shading the water and, as a consequence, reducing algae growth.
• making use of space of water bodies, as opposed to using more land.

Adding to the above-mentioned advantages, a major benefit of these systems is the positive effect they have on climate change. FPV systems cool the water bodies they are installed in by absorbing the energy of the sun, shading the water beneath them and generate energy without any CO2 emissions. Both actions compensate in a small part the effects of global warming on lakes and reservoirs. If these systems were more broadly adopted, they could become the best method to combat this issue while at the same time, producing clean and renewable energy.

V. Examples

The first time FPVs were implemented was in the year 2007 in Japan. This project was carried out by the National Institute of Advanced Science and Technology under the name of *The Aichi Project*. This first deployment was aimed to be a proof of concept as well as an analysis of the effectiveness of the PV modules under the floating condition [4].

In Bubano in Imola, Italy, a project made in collaboration between two local companies was also put forward. It was rated for 500kWp (KiloWatts Peak) and situated in a lake. This system consisted of “floating islands” connected by a grid where the modules are placed. The system was named *Flotovoltaico* [4].

Fig. 4 FPV system in Burbano, Imola, Italy.

In October 2011, the Korean government company K-Water installed a Floating PV on Hapechon dam reservoir rated for 100kWp and a second installation in 2012 of a system rated for 500kWp. K-water is currently researching on technologies that could allow for solar-tracking panels, which could boost the efficiency of FPVs even further [7].

(a) 100kW (b) 500kW

Fig. 5 K-water’s FPV systems.

One of the largest scaled projects was in the year 2014 in Okegawa, Japan. The FPV system was developed by the French company Ciel er Terre. It was installed on a water reservoir and rated for 1157kWp [4].

Fig. 6 FPV system in Okegawa, Japan

VI. Conclusion

The effectiveness that FPVs have to attenuate climate change effects on lakes and water reservoirs is evident while considering all the factors discussed in this paper. Even though there is a need for more solutions to reduce climate change, FPVs are an effective way to achieve this and should be supported to reach their full potential.

Currently, this technology is not accessible to everyone due to its high costs, a situation that could be reversed if more investments are made to support climate action initiatives. This is something that, according to the research done in this paper, appears to be slowly but surely happening, especially in the eastern countries.

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