

# A RESEARCH ON FLOATING PHOTOVOLTAIC POWER PLANT FOR IRRIGATION RESERVOIRS

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## Abstract

This era of rapid industrialization and human need of being upgraded with latest gadgets have caused heavy increase in electricity requirement. Orthodox energy resources are decreasing in amount and increasing environmental concerns due to pollution caused by them. Looking for alternative resource has introduced solar PV system as one of the most growing industries all over the world [1]. And land is one of the key commodity for erecting solar PV system. On a different note, up gradation of agriculture has converted conventional systems of irrigation into pressurized systems which has created the need of reservoirs and considerable power units for driving pumps. For the small scale farms, power consumption costs are big part of total cost which creates heavy load on the farmers [2]. Constant availability of sufficient water quantity for farming is another prime concern of farmers. Not achieving economic stability has led to suicide incidents of farmers across the globe. Above mentioned course of events has emerged Photo voltaic floating Cover System (PFCS) as a vital solution as it is erected on reservoirs which saves land. It saves water underneath it from evaporating and produces electricity required that too with increased efficiency compared to normal solar plant due to lower temperature of panel caused by water underneath it [3]. The present paper gives an overview of Photo voltaic floating Cover System (PFCS).

## 1-Introduction:-

Due to ever increasing population and pollution of world, we require energy resources which are efficient along with being environment friendly. Also considering the present scenario, the world is moving towards decentralized energy resources, solar energy topping the list of it. Inclination of country's economy towards agriculture and necessity of it has led to heavy increase in demands of making agriculture industry modernized... Land and water being the primary resources, play vital role in controlling production cost of agriculture industry. Photo voltaic floating Cover System (PFCS) apart from having numerous advantages like increased efficiency, sustainability and future scopes, saves both water and land. Especially in countries like Japan and Singapore where real estate is extremely costly due to population density and land scarcity, PFCS can be a perfect solution [5].

Modernization of irrigation system has increased the crop production but along with it, power consumption for the same has increased too. In the arid and semi-arid areas, water is too scarcer resource. To deal with this situation, in the scenario like India, where large initial investment, compact land size, scarcity of water and tough market competition are some of the key words that describe agricultural scenario, PFCS has emerged as an innovative and sustainable solution.

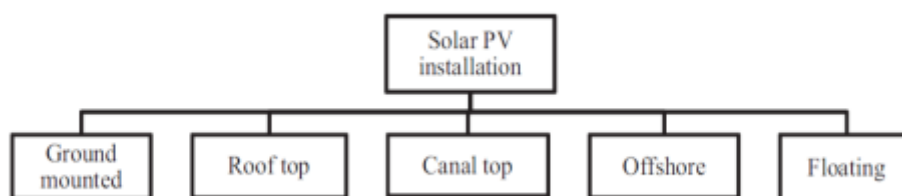


FIG.1 TYPES OF SOLAR PV SYSTEMS [14]

## 2-Photo voltaic floating Cover System (PFCS):-

The PFCS is a new concept, with no commercial deployments being under taken and less demonstrator projects being deployed globally[22].Up gradation of agriculture system has increased the need of converting conventional system into pressurized system which increased the efficiency of conventional system from 45% to 75-95% [18]. Solar energy being an indirect source of energy, needs two basic components, i.e. a collector and a storage device. Solar panel which acts as collector for solar radiations are of 3 types, i.e. flat plate collector, focusing collectors and passive collectors. Flat plate collectors are being used frequently these days. [4] In most cases, these systems demand water reservoir and water proofed storage systems with geomembrane has come out to be most efficient solution for it. Using PFCS over this reservoirs will not only serve the purpose of fulfilling the power supply requirement for pressurized system but will also save water from evaporating. Energy generated from photo voltaic though a renewable source, maintains a less efficiency of around 15% in its long life use [28].

## 4-Basic components of PFCS:-

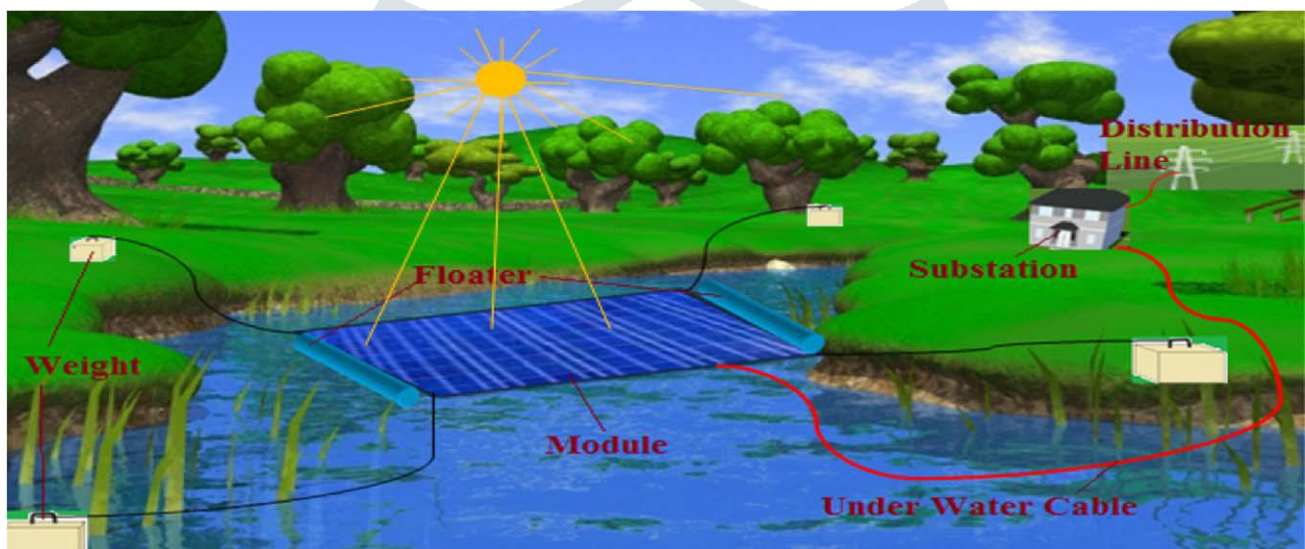
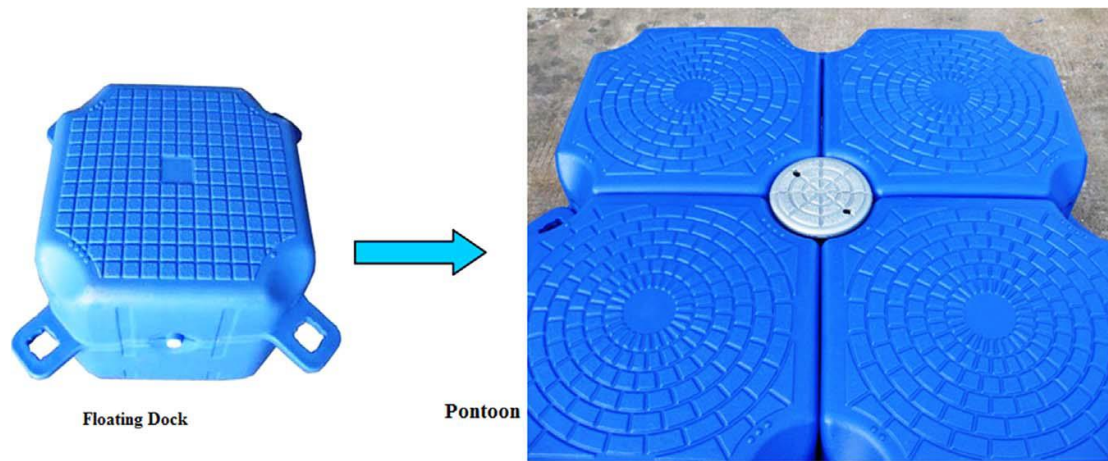


FIG.2 Diagram of basic components of PFCS [13]

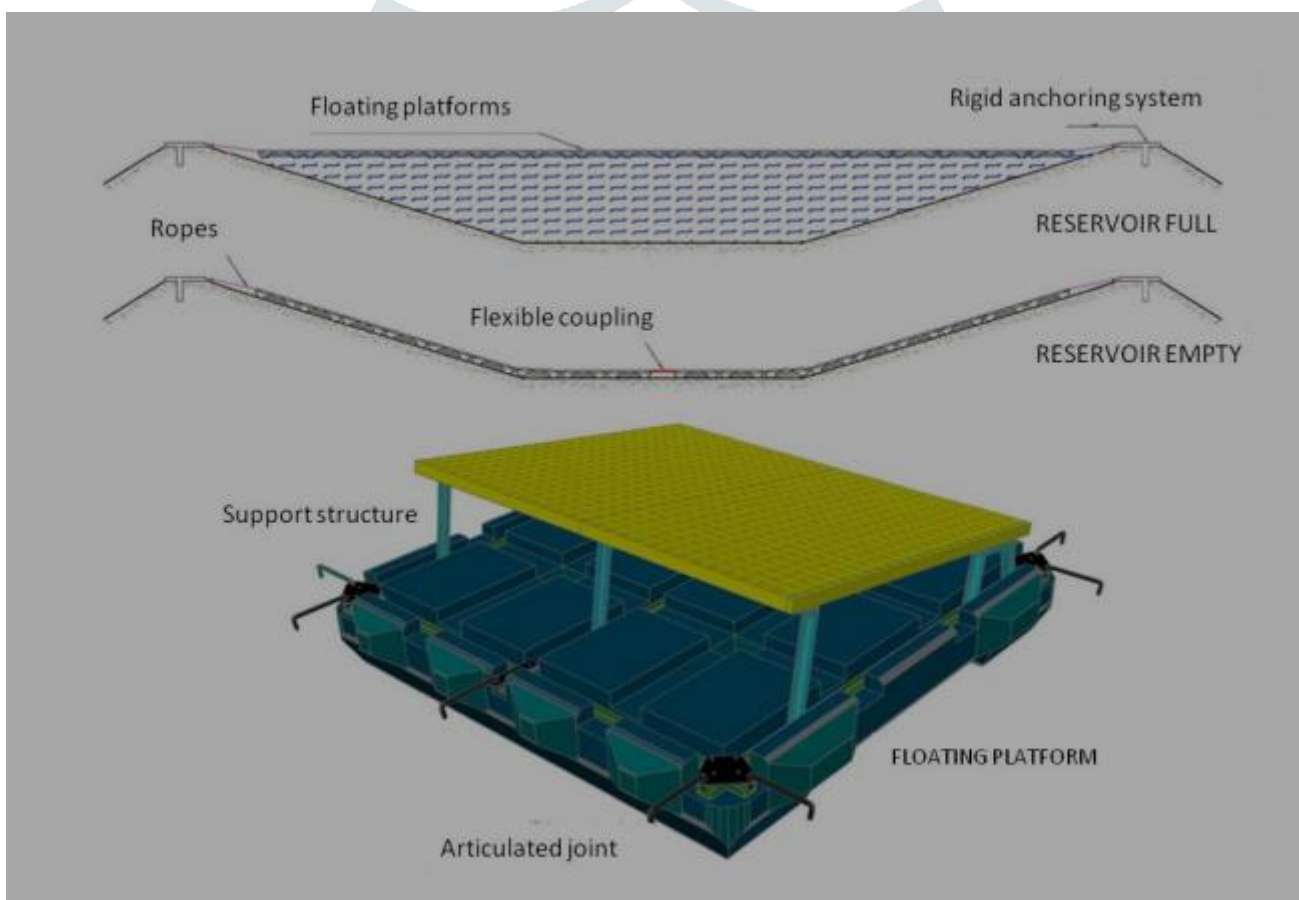
**Floats-** They are air tight plastic components which are combined together to create a pontoon. They are designed with ability to provide enough buoyancy to support themselves and weight upon them which is of solar panel.

**Pontoon-** As per the available space, several floats are combined together to support series or parallel combination of solar panels. They have enough buoyancy to support heavy load of solar panel according to requirement and space availability. [26, 27]



**FIG.3 PONTOON STRUCTURE [13]**

**Articulated metal couplings:** They are metal chains or cables which links pontoons together and allow its vertical displacements so that the deck can adapt to concave profiles of reservoir.



**FIG.4 COMPONENTS OF PFCS [8]**

**Mooring system-** They are used as a substitute to articulated couplings. Just like Articulated metal couplings, they keep pontoon together and prevent them from floating away [21]. It is complex and expensive to install them in deep water.

**Solar PV module-** Crystalline PV modules are being used conventionally in floating solar systems. Almost all metal decay with time therefore substitute like polymer made frame is needed. A typical PV module converts 18% of incident solar irradiance into electrical energy depending upon type of solar cell being used and climate of surrounding available [14].

**PV module support structure** - They are made of UF and CF cold-formed metal frames [13]. They must be able to sustain the weight of the PV modules and impart wind forces from the pontoons to the anchoring system which is present at perimeter.

**Flexible couplings:** They make pontoons move in relation to one another so that the system can adjust to different water levels. They are made of rubber or MDPE (Medium Density Polyethylene) straps can stretch until restricted by the rigid polyester or nylon ropes which come into action when the extreme displacement has been gained.

## 5- Essential design factors to be considered for improved efficiency:-

Electrical efficiency of the solar power plant depends on the surface area of the solar panels facing sun. In design of PFCS, the dimensions of the module must be modified to commercial photo voltaic panels. Also, the modules shall cover the maximum possible water body to prevent water evaporation [15]. Along with the surface area, inclination of the panel and its orientation plays vital role in governing efficiency of power plant. All driving parameters are described in detail in below given list:-

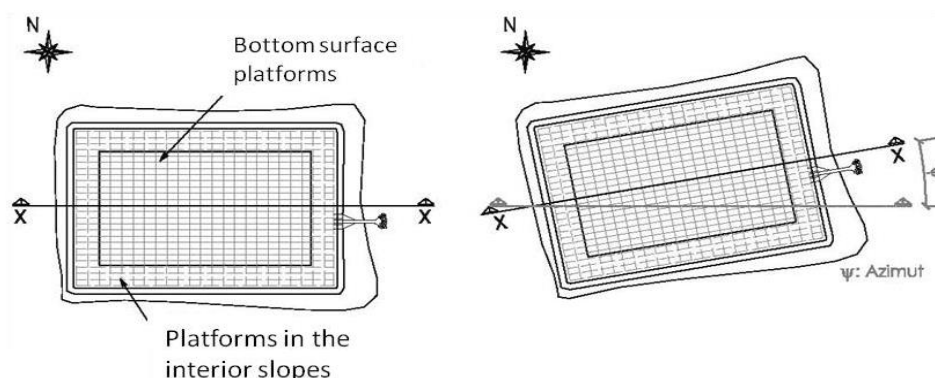
1- Floating structure characteristics- There are mainly two characteristics which govern the efficiency of PFCS. The first one is, it shall be designed according to standard dimensions of the commercially available solar panels so that assembly process becomes smooth. Secondly, the cover of solar modules must cover the maximum area of reservoir beneath it to prevent evaporation of water. Apart from that feasible distance consideration between solar panel rows to overcome shading effect, designing path for ease in maintenance process and number of solar modules installed are also significant parameters which shall be considered.

2- Inclination angle of panels- Inclination angle of solar panels is deciding factor while calculating distance between rows of solar panels. Classification of solar cover system based on inclination of panels is given below [8]:-

Continuous grid: - For inclination angle  $\leq 10$  shading effect is negligible and space between panel rows isn't required.

Discontinuous Grid: - For inclination angle  $> 10$  shading effect becomes significant enough to be considered and space between panel rows works as means of preventing it.

3-Orientation of solar modules- As the Sun does not rise exactly in the east, but rises to the north of east and sets to the north of west, [7] it is necessary to keep the whole system oriented towards south so that solar irradiance strikes in such a manner that maximum efficiency can be manifested from same input. Otherwise if conventional solar panels are laid flat then they will create about 15% less energy compared to panels which are installed at the more typical 15-30° facing the south[29].



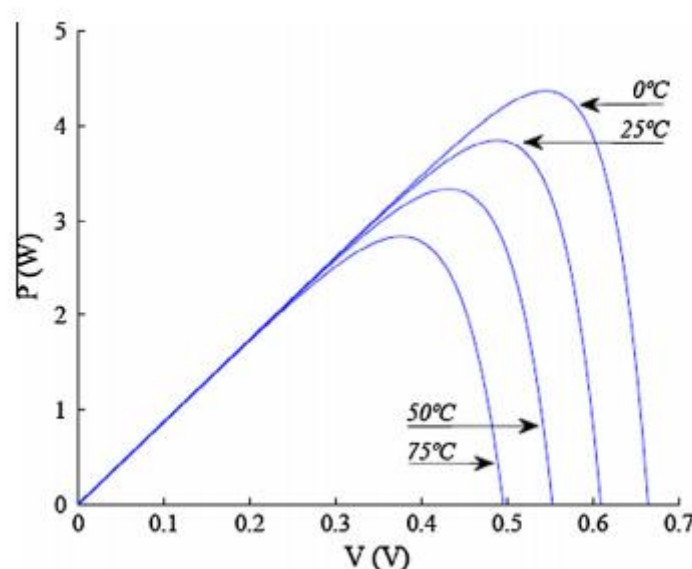
**FIG.5 ORIENTATION OF THE PRICIPAL AXES OF A RESERVOIR [8]**

4-Geometry of floating module- It shall be adaptable enough to get used to changing depths of water surface and its volatility. It requires site specific planning to make this kind of designs successful.

5- Temperature of PV module-In photo voltaic (PV) system, the electrical efficiency of the system reduces dramatically as the PV module temperature rises. So, in order to derive greater electrical efficiency, the PV module need to be chilled by removing the heat [19] and for that some arrangements needs to be done to use the water of reservoir underneath.

### 5-Advantages of PFCS are mentioned below:-

- Use of reservoir surface for solar panel installation stops devastation of ecological system and it also saves land which can be used for further agriculture related uses.
- There is no maintenance associated with clearing away ground-based vegetation
- There is no extra water needed to clean the panels as the water from the water body can be used to clean the panel [4].
- Evaporative cooling of solar panels and cables due to water body underneath it amplifies efficiency of PFCS in significant manner.
- PFCS reduces the formation of waves and, thus, the erosion of the banks of the reservoir is also prevented [20].



**FIG.6- P-V characteristic as a function of temperature of floating module [6]**

-Cover of solar panel restricts solar rays from entering into reservoir, reduces photosynthesis process in plants present at reservoir bottom, prevents algae growth and keeps water quality high.

-Essential resource like water is saved from evaporation as due to solar panels present on surface, water doesn't come in direct contact with solar irradiation. It can reduce water evaporation by up to 70%.

-This renewable power generating system reduces use of conventional resources which are being scarier day by day.

-It produces clean energy without causing any damage to environment around it and thus concerns about growing pollution does not arise for this system.

-Floating solar will not displace people or submerge land and thus require minimal initial cost.[11]

-Floating solar farms could also have applications in major catchments and hydropower dams; enhancing their electricity generation potential. [12]

-The floating platforms used in PFCS are 100% recyclable, utilizes high density polyethylene which can withstand ultraviolet rays along with corrosion [14].

-PFCS has shown better generation efficiency by over 10% when compared with the general PV systems which are installed overland.[17]

-Installation is relatively easy to implement, since the floatation structure can be assembled without heavy equipment [25].

## 6 - Difficulties in installation of PFCS:-

The biggest challenge in designing PFCS is to keep it afloat while it bears loads which are being imparted on it by surrounding factors like wind force. Below provided issues also needs to be overcome while installing PFCS system over reservoirs:

1- Salt corrosion, loss of efficiency due to drying salt or fogging of glass and biological fouling are problems that have to be encountered when dealing with a marine environment [20].

2- Floating systems needs to be flexible enough to withstand sudden and irregular movement of water surface during floods, heavy winds, cyclones.

3- As far as economic factors are concern, high initial investment and high maintenance cost may also refrain investor from investing in such system of which payback period is large.

4- Strength and vibration related concerns are more common in PFCS because of reservoir waves and winds. It may lead to formation of cracks at micro level which further propagates and may create electrical efficiency related issues.

5-In initial years, the cost of power generation from PFCS system is 10 times more costly than Conventional system which is fossil fuel based [14].

6-The installation of PFCS cannot be done in ocean as the ocean tide affects the placements of floating solar panels constantly [24].

## 7-Conclusion:-

The efficiency of PFCS is 11% higher and reduces evaporation of water by 70%, however the initial cost of such power plant is 1.2% times higher than the orthodox solar power plant [14]. In brief, PFCS systems are promising alternatives of conventional power generating systems and especially for modern pressurized agricultural technique. In regions where water is scarce commodity, this system can be a bliss to owner.

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