# Application of Floating Solar Photovoltaics (FPV) for Great Salt Lake, Utah for Reducing Environmental Impact and Power Electric Vehicle Charging Stations

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## Abstract

**Lake water is significantly lost due to evaporation and sometimes as high as 20% of the total inflow. Given that floating solar photovoltaics (FPV) are proven to operate at higher efficiencies due to the inherent cooling mechanism available from the lake water, their applications have become a feasible option for the Great Salt Lake, Utah, which is losing a significant amount of water every year due to evaporation. Although lakes are significantly smaller in terms of holding water when compared with other sources, they develop an ecosystem and habitats around them. FPV poses a threat to the local habitat, but when there is an absence of local habitat in the water bodies, they become the promising solution. Additional considerations to allow the growth of local habitats without compromising sunlight exposure, artificial lighting underneath the FPV is a feasible solution. Using the past data on how much water was lost at the Great Salt Lake, Utah, a solution by utilizing the untapped potential of the FPV system was analyzed both from energy and water conservation perspectives. Some considerations around using the generated power to meet risen energy demand from electric vehicle charging become the subject of exploration when decarbonization efforts have materialized.**

**Keywords: Electric Vehicle Charging, Energy Savings, Floating Solar Photovoltaics**

## 1. Introduction

A floating solar photovoltaic (FPV) system is mainly a floating set of solar panels on water bodies. These have potential advantages in reducing evaporation losses by utilizing the water for cooling purposes. There are several other benefits, such as a reduction in land usage and resilience to floods. The key to the successful application of FPV lies with the type of water bodies they are exposed to. For example, when applied to a moving water flow, it may interfere with the anchoring mechanism to keep the FPVs in place, whereas when applied to still water, it may experience greater stability from movement. Some large-scale FPVs worldwide include 320 MW (Dezhou Dingzhuang) in China [1], and 100 MW (NTPC Ramagundam) in India [2]. Some FPVs around the US include 4.78 MW in Healdsburg, California, 4.4 MW in Sayreville, New Jersey, and 1.8 MW in Windsor, California.

Typical FPVs use floats or pontoons to allow buoyancy and are anchored to stationary structures. The mooring system may be either rigid, taut, catenary, or compliant depending on how it is supported [3]. Some other concepts of structural installation include rafts with parallel HDPE cylinders, panels on individual floats with built-in rails, floating platforms, partially submersed floating structures, and flexible neoprene sheet structure [4]. Integration of the FPV system with the off-shore wind turbine system allows a mixture of renewable energy generation from both solar and wind energy resources. Additionally, the concept of utilizing FPV power for generating compressed air storage to drive turbines for power generation is an option where the feasibility of a battery energy storage system becomes poorer than an air energy storage system.

Great Salt Lake loses about 2.9 million acre-feet (or 944,968 Million gallons) due to evaporation and observes the highest evaporation rates during summers [5] [6]. Floating lattice structures offer 40-50% reduction of evaporation losses and published literature has presented the water savings in (cubic meters/ MWh) ranges between 0.8-30 [7] [8]. Other known water conservation measures include rainwater harvesting, irrigation control, soil amendments, and water rebate programs [9]. There is a significant contribution by lake to the economy of Utah by offering jobs and providing resources for lithium extraction and producing magnesium. Evaporation loss not only reduces with FPV application but also reduces with an increase in FPV occupancy [10] [11]. Mainly large number of existing brine shrimp and brine flies attract the migratory birds for food resources. And the lake acts as a great place for them to rest, energize, and breed.

The major components of an FPV system comprise PV modules, floats/ pontoons, a combiner box, submersed cables, anchored support cables, and a central inverter. The floats/ pontoons allow the modules to stay afloat throughout the year, whereas the anchored support cables allow the FPV to remain intact in each location. FPV offers an increased efficiency of operation as it takes advantage of the cooler water body. Many concepts for further improving efficiencies include adding a sprinkler system. These added advantages certainly drive the successful adoption, but some barriers from a regulatory standpoint include an unclear path for environmental approval and a lack of certainty on the loss of water rights [12].

Researchers have found that about a 2-11% drop in temperature is observed for an FPV installation, and thus, 8% higher efficiencies are offered with both mono and polycrystalline PV modules for this application [4]. The current research focuses on the preservation of water by FPV application, which becomes the basis for this research on FPV applications for the Great Salt Lake in Utah. The lake has observed diminishing water due to draught conditions in the past; hence, measures for water conservation become an eminent choice for providing a sustainable future to residents around the lake. This paper is divided into sections where methods for developing an FPV for the Great Salt Lakes are presented. Results, discussion, and future scope of this study were presented in the respective sections.

The ecosystem must be preserved to allow sustainable development, as the aim of sustainability is to ensure a positive outlook for the future generation without compromising the needs of the current generation. When sustainable development is considered, the ecosystem impacts of artificial establishments such as FPV become pivotal. Large establishments on land cause movement of soil, wildlife, water resources, and so on. To limit the impact on the land and its respective ecosystem, FPV application on water bodies drives the need to ensure there are no harmful impacts on the ecosystem within the water body. This paper focuses on the sunlight lost due to the FPV application and measures to restore it with artificial means.

In previous research, design aspects of FPV were laid out, along with major challenges from environmental permitting and impacts on ecosystems. However, there is no research available that focuses on the application of FPV specific to a location that is prone to loss of water, such as in Great Salt Lake, Utah. Although Utah got its first FPV installation in 2024, there is no project, there were no publicly available resources to confirm any planned project from the Great Salt Lake. This paper becomes a resource for planning departments for major capital projects focused on cleaner energy and enhancing the ecosystem by application of new technologies. Better materials for solar PV modules improve efficiency and are eco-friendly in nature for FPV application, reducing impacts on the ecosystem due to contamination of water from the materials. This aspect of improved materials design has become a subject of research for many.

## 2. Methods

The methodology is shown in Fig. 1; mainly, the lake surface area becomes key for determining the usable surface for FPV application. Evaporation loss reduction and ecosystem preservation become factors that drive the selection of the usable surface for FPV application. For example, a given type of ecosystem conservation may restrict the installation of a larger FPV system, whereas when a greater reduction of evaporation losses is concerned, a larger FPV system may be required. Based on the available surface area, the total count of solar panels that fit in this area is calculated. By use of open-source software (such as the NREL System Advisor Model), the total power generated from a typical system is calculated. However, improvement in the efficiency of the FPVs availed in summer months from the ambient water results in further increased energy generation. The given FPV may either be tied directly to the power grid by inverters or utilize large battery energy storage systems.

FPV system design is dependent on how well the system is grounded and bonded together to improve safety. Most electrical equipment and wiring methods become listed for damp and wet locations. Protection devices ensure additional measures for ground fault protection. Maintenance and access to the FPV system for technicians become key when it comes to the spacing of arrays. Electrical safety measures to ensure no electricity is conducted through the water body and possible cause electrocution of the water life is key from design engineering prospective of solar PV systems. Some of the local codes and standards in electrical engineering design published by agencies such as IEEE, IEC, NFPA, NEMA, UL, and so on ensures the compliance with safety. However, with growing FPV there are lessons learnt and thus they become driving forces for any improvements to the safety design and installation on large scale. For example, NEMA standards govern the type of enclosures for electrical equipment that are suitable based on environmental conditions. Similarly, the National Electrical Code governs the installation of the wiring, equipment, and sizes of electrical over current protection devices for the system. Since the installations have a heavy component of electrical design, the standards are subject to enforcement by the local government agencies. However, many standards from architectural, structural, environmental, civil, mechanical, and plumbing come into the picture when the system presented in this paper is designed and constructed.

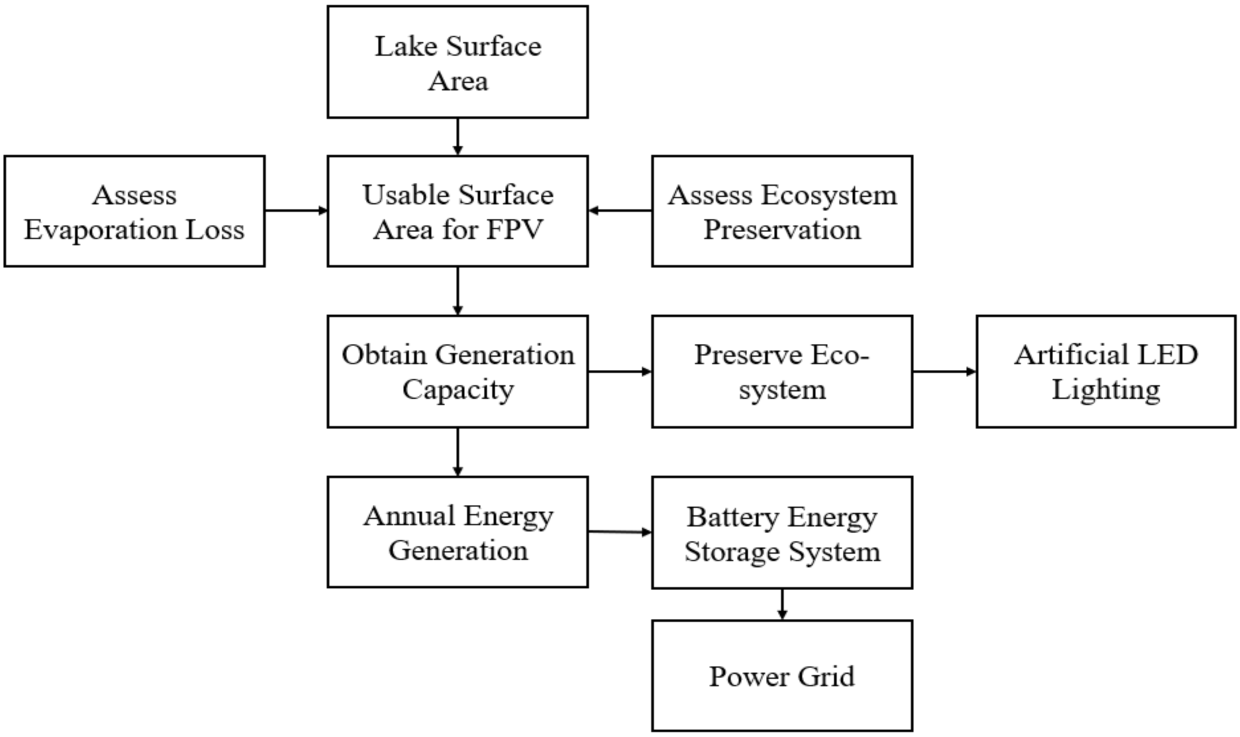

**Fig. 1. Methodology**

Some electrical design considerations for FPV design include appropriately sizing arrays, tilt angle, DC and AC conductors, inverters, conduits, overcurrent protection devices, sprinkler system pumps, and so on. Some architectural design considerations include selection of color, layout of arrays, and so on. Some structural aspects include the size of the anchoring system and cables. Similarly, for mechanical and plumbing, the considerations are around sizing the pumps for a sprinkler system. Although designs are complicated and safety is must the compliance with standards would allow minimal risks, additional safety measures are recommended. For example, structural integrity of the entire system is key to long-term success.

A commercially available 700W solar panel typically has dimensions of 7.83 x 4.27 x 1.38 (inches). When a fixed tilt of 30 degrees is applied, the typical area covered above the floats becomes 28.96 sq. inches. To allow maintenance of the panels a spacing between continuous racks was taken as 3 feet. This spacing allows enough room for cleaning, maintenance, or additional room for the water sprinkler pumps. Water sprinkler pumps to ensure additional cooling and cleaning purposes becomes an viable option when FPV efficiency improvement is required beyond otherwise available naturally from the given system.

The total surface area of Great Salt Lake is estimated to be around 1699 sq miles. An area of 25 sq miles was selected for FPV application. An 11,670 MW installation with 700W modules, each totaling 16,672,500, allows an annual generation of 18,011,703,296 kWh. During the summer months, generation improvement is considered from cooling effects of water, and the total annual generation becomes 18,458,457,134 kWh. Fig. 2-3 shows annual energy generation in kWh without the effects of water cooling. Fig. 4 shows an improvement in annual energy generation from cooling effects of water (by 8% during summer months). Fig. 5 shows the footprint of a 25 sq miles FPV over the lake. Fig. 6 shows a concept of FPV without LED lighting and Fig. 7 shows a concept of LED lighting and its controls for ecosystem preservation. The selection of appropriate correlated color temperature (CCT) and distribution pattern of the light depends on lighting assessments using simulation software. This paper presents the idea of introducing LED lighting to overcome lost daylight exposure to the local ecosystem underneath the installed FPV. Some type of lights cause minimal interference with regular circadian rhythm.

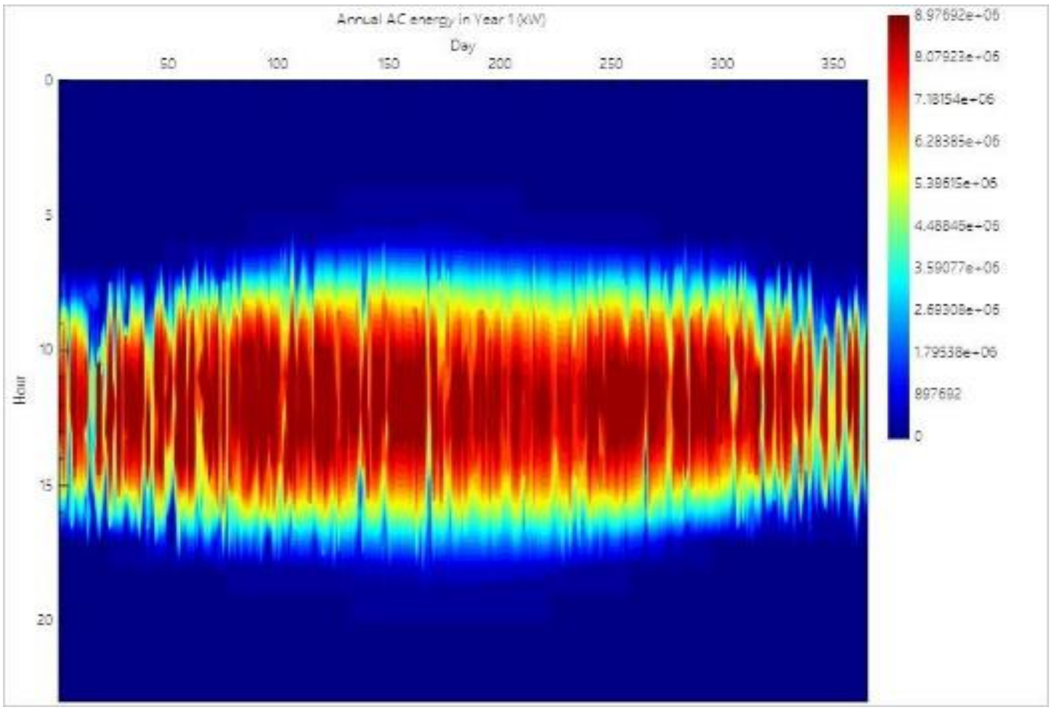

**Fig. 2. Annual Energy Profile (kWh) without effect of water body**

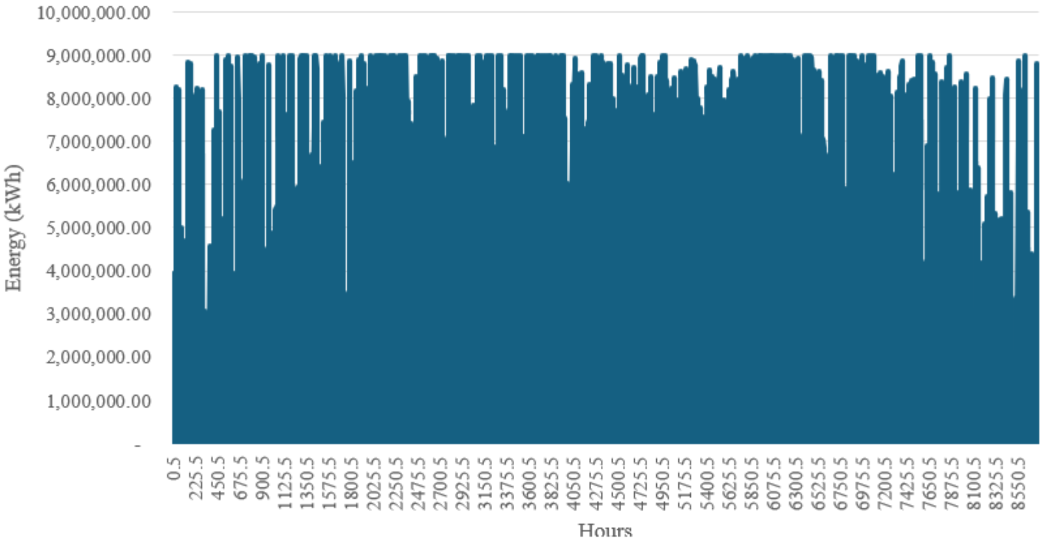

**Fig. 3. Energy (kWh) without effects of water body**

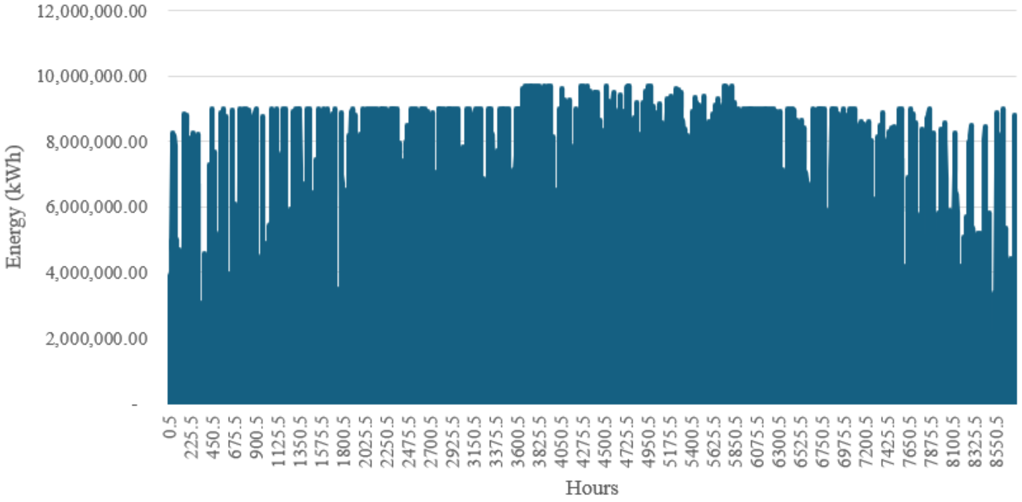

**Fig. 4. Energy (kWh) with effects of cooling from water body**

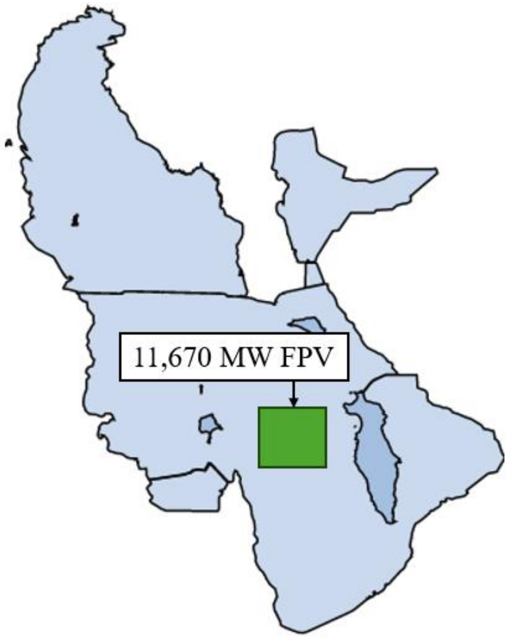

**Fig. 5. Footprint of FPV at Great Salt Lake**

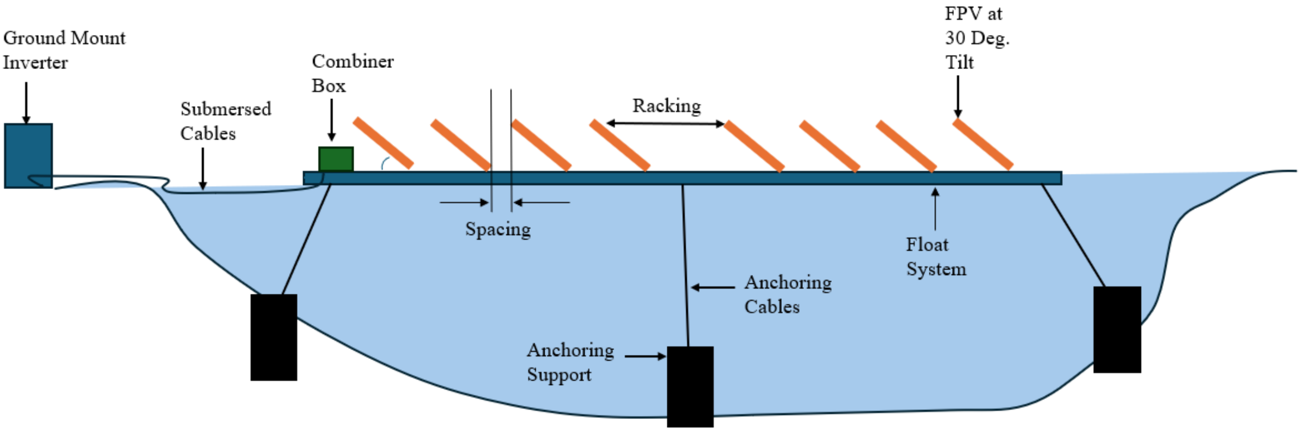

Fig. 6. FPV System

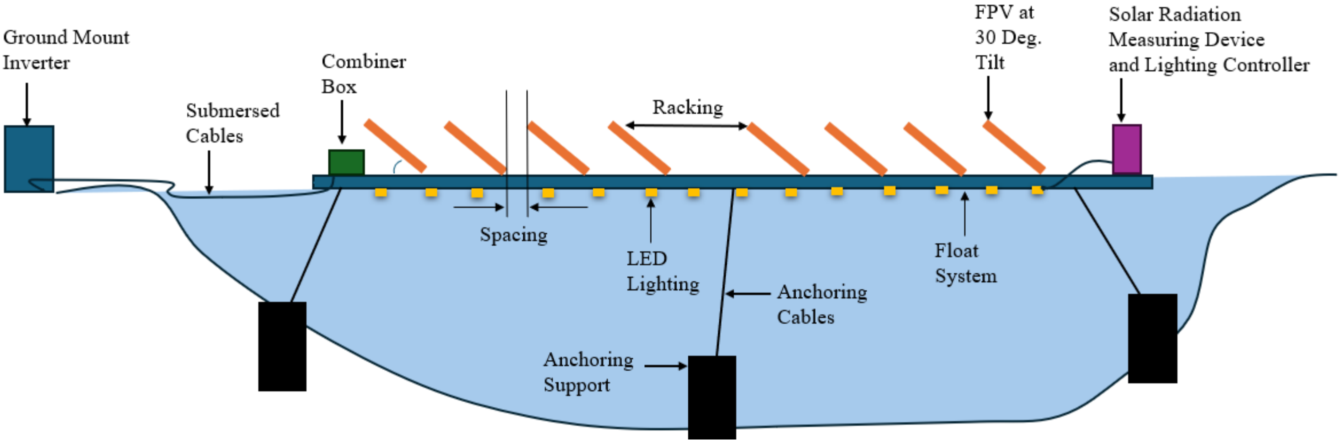

Fig. 7. LED Lighting Concept

## Cost of Installation

The typical cost of materials and labor depends on the location, but in Table 1, the average costs around the Great Salt Lake area were considered. The labor was accounted for as a fixed percentage of the overall cost. Based on the geographical location the materials and labor costs vary. Additionally, design engineering costs were ignored in Table 1. However, a certain percentage of the total cost (such as 10% of the overall construction cost) may be a good starting point for estimating the engineering design engineering costs for the FPV system. Many firms are independent design engineering firms, so separate estimation of design costs becomes a choice for cost estimation. Several economic comparison studies [13] have indicated positive returns on investment.

Table 1. Cost of Installation

| S. No. | Material/ Labor | Cost ($M) |
|---|---|---|
| 1 | Solar Panels | $6,002.10 |
| 2 | Inverter | $350.10 |
| 3 | Submersible Cables | $142.56 |
| 4 | Submersible Connectors | $8.34 |
| 5 | Combiner Boxes | $41.68 |
| 6 | Sprinkler System | $5,833.63 |
| 7 | Floats/ Pontoons | $10,454.40 |

| | | |
|---|---|---|
| 8 | Anchoring System | $104.54 |
| 9 | LED Lighting | $333.45 |
| | *Sub Total* | $23,270.80 |
| 10 | Labor for Installation | $4,654.16 |
| | *Total* | $30,252.76 |

**Table 2. Savings**

| S. No. | Savings | Cost ($M) |
|---|---|---|
| 1 | Energy | $1,962.13M |
| 2 | CO2 Equivalent | $1.08M |
| 3 | Water Conservation | $5.84M |
| | *Total* | 1,963.21 |

Return on investment is dependent on the total savings achieved at the end-of-life vs the total investment at the beginning of the project. Typically, solar PV systems have a return on investment between 8-15 years of installation. However, the returns based on savings projected in Table 2 project is about fifteen (15) years from the initial investment since here carbon credits and water savings were accounted for.

**Conservation of Ecosystem**

Illumination and its type required to compensate for lost sunlight for water life is dependent on the intensity of light level and type of radiation (such as wavelength) received at the water surface during the given time-of-day. The ideal illumination level for water life to survive and live healthily is a key factor when the addition of artificial illumination is concerned. Tunable-white lighting within a correlated color temperature range of (2,700-5,000) Kelvin typically matches with the sunlight. Although the benefits of sunlight for humans mainly revolve around Vitamin D supplementation, improving the circadian rhythm, healing both physically and mentally, and reducing stress levels, for water life, they mainly focus on photosynthesis for the plants that become food resources for the local ecosystem. It is proven that the algal growth increases with the application of artificial lighting [14]. An LED lighting system installed underneath the floats/ pontoons is a suggested approach to increasing the compromised light levels to the water life underneath the FPV.

The LED lights installed underneath the floats will be powered by FPV, and the controllers increase or decrease the light levels based on sunlight conditions at a given time of the day. Luminous meters installed at uncovered water surfaces allow the controllers to accurately alter light levels for covered areas with LED lighting. LED lighting is inherently energy efficient when compared with other types of commercially artificial lights, such as metal halide or high-pressure sodium. However, achieving a soothing, least harmful, and closest match to sunlight becomes a design aspect for lighting designers and manufacturers.

Additionally, during installation, extreme care to ensure no contamination of water resources allows a reduced impact on the ecosystem. 211.34 gallons/ MWh water conservation is expected to account for 3,895 million gallons a year of water savings for a 25-square-mile covered surface. Authors have indicated that the carbon footprint of FPV is 49 gCO2eq/kWh [15], thus for the given 11,670 MW installation generating 18,458,457,134 kWh annually the carbon footprint equates to 904,464,399,566 gCO2eq/kWh. Fossil fuel-based power generation emits 0.86 poundsCO2eq/ kWh or 390gCO2eq/kWh. Thus, the total reduced emissions from FPV become 6,294,333,882,694 grams of CO2 or 6.3 million metric tons of CO2. Assuming one carbon credit at $0.173, the total savings is $1.08M.

### Electric Vehicle Charging

Electric Vehicles are growing in the market at a rapid rate to combat the energy crisis. In [17], a significant amount of energy demand is added to the power grid from large-scale electrification. This leads to the use of renewable energy to power the added demand. The FPVs at Great Salt Lake, Utah, are the perfect candidates to supply power to the electric vehicle charging stations or hubs. To reduce transmission and distribution losses from power lines from the FPVs to charging stations or hub. The charging stations can be located within optimal distance from the FPV installation. This combined usage of FPV and charging stations further reduces carbon emissions.

## 3. Results and Discussion

As per the simulation results, an annual energy generation of 18,011,703,296 kWh without the impact of the cooling effect was obtained. However, upon accounting for the known efficient improvement from the cooling effects of water, a further improvement of 18,458,457,134 kWh was obtained. This equated to a reduction of evaporation losses to 3,895 million gallons a year ($5.84 M) and 6,294,333,882,694 grams of CO2 equivalent ($1.08 M). Local ecosystem and water life conservation from lost sunlight were compensated using artificial LED lights mounted underneath the floats. A controlled operation to ensure the LED lighting levels match the sunlight becomes a feasible solution. The cost of the 25 sq miles of FPV system was obtained by enumerating major elements of the system. Given the return on investments gives a positive outlook when water conservation and CO2 reduction are considered, environment protection agencies are recommended to pursue this option. Although regulatory authorities do tend to see some resistance due to the lack of FPV success, this paper quantified the gains from FPV application for the Great Salt Lake in Utah. Recent projects in 2024 in Utah have shown some interest in FPV from the local agencies. A large-scale adoption lies in the hands of policymakers, government officials, public awareness, and many other factors. Combined usage with electric vehicle chargers becomes a great candidate in reducing carbon emissions.

## 4. Future Scope

The FPV has been a growing concept and has been explored for almost many years now. But when we consider the environmental impacts of the FPV installation, there is limited information available. The approval processes for permitting by the environmental agencies due to the lack of impact become a discouraging factor for their growth. Since there is no land space utilized for this application, many may see it as an excellent solution for densely populated areas or at least where the conservation of the land is concerned. Many canal systems can take advantage, and a more robust design may allow the FPVs to fully off-float in case of a total loss of water in the water body. Neither the durability of submersed electrical systems nor the structural integrity of the floats and anchoring system limits the FPV application. However, the governing agencies become key players in decision-making processes to allow FPV at a large scale. Effect on water life is the subject of study when FPV materials are known to come in close contact with the water life. It either totally blocks the sunlight or reduces it to very low ranges, thereby harming the water life.

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Pravin Sankhwar is an engineering professional and holds professional certifications with State licensing boards in the US. His approach in engineering practice is oriented towards green energy resources. Professional and academic careers in electrical engineering were the foundation for the development of this research work.