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Comparative Analysis between Floating Solar Photovoltaic Power Plant and Overland Photovoltaic Power plant

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ABSTRACT: Floating Photovoltaic (FSPV) power plant on any water body is a Solar Photovoltaic (SPV) plant that is installed on water, instead of land. The water body may be lake, pond, river, canal etc. There are many benefits to FSPV power plants versus SPV plants. Some of them include: (i) Increased electrical energy production due to low module temperature; (ii) Reduced water evaporation from the water body, saving valuable potable water; (iii) No need for a piece of land to install the power plant because the FPV system floats on the water; and (iv) Shorter power transmission lines due to the proximity of water bodies like ponds. In this paper comparative analysis is done for the FSPV and overland solar PV plant. Which give difference for generation capacity by using simulation software PVsyst. And analysis of difference between cost economy of FSPV and overland solar PV plant. Which give result that the FSPV plant generate energy annually by 3.12 % more than the overland solar PV plant. The capital cost of FSPV is about 17.48% higher than Overland Solar power plant.

KEYWORDS: PVsyst, Energy, floating photovoltaic plants, solar photovoltaic plants, solar radiation, temperature

I. INTRODUCTION

Country's power demand will increase at an average rate of 6.5% in 2022 and 2024 according to International Energy Agency. The rapid increase in overall energy demand strained coal and natural gas supply systems, driving increasing wholesale electricity costs. Many problems have arisen as a result of the use of fossil fuels as a key source of power generation. As energy supply is still primarily reliant on conventional power plants, this has put a great strain on fossil fuel resources. Therefore, there is a need to find alternate energy sources that can generate clean, green and affordable power. A viable alternative is to use "Renewable Energy Sources" such as sunlight, wind, flowing water, the earth's internal heat, and biomass such as energy crops, agricultural and industrial waste, and municipal waste. (Albadi et al, 2014). Because of sunlight is the most plentiful renewable energy resource, solar energy is considered to be the most promising choice among renewable energy sources. Floating Solar Photovoltaic (FSPV) is an appealing alternative technical solution to the problem of rising solar project costs caused by rising land prices. Because of the scarcity of land, the FSPV system is rapidly gaining popularity. Floating solar photovoltaic panels have numerous advantages over overland installed solar panels. So Comparative analysis performed for floating solar power plant and overland solar power plant to find out generation difference between both and cost economy of both the solar PV system so it is found that which system is more feasible.

II. RELATED WORK

Choi (2014) studied the system designed to combine newly created floating photovoltaic technology with current land-based solar technology. They found the floating PV system has a generation efficiency that is 11% higher than the overland PV system. They demonstrated the superiority of floating PV systems by a generating amount comparison of 2.4kW, 100kW, and 500kW floating PV systems built by K-water.

Yadav *et al.* (2016) combines recently created floating PV technology with land-based technology that is already in use. Their goal is to evaluate and contrast the performance of PV systems with conventional and floating bases. The system has a 250W installed capacity. The floating system has demonstrated higher generating efficiency as compared to the traditional method. The research revealed that FPV offers more efficiency and overall power increase.

Patil (Desai) et al. (2017) demonstrated the techno-economic feasibility of this technology linked to the SFIP by simulating an FSPV power plant at the System Advisor Model (SAM) using techniques and parameters from real FSPV projects. The economic results are a positive net present value (NPV) of \$2.8 million and a payback period ranging

from 10.5 to 11.7 years. The levelized cost of electricity (LCOE) of \$32.17/MWh is less than the current energy rates paid by the SFIP administrator, and final consumer water costs could be reduced by 40%. Furthermore, the FSPV had a capacity factor of 21.1 percent, and the system was able to reduce water evaporation from one of the SFIP's reservoirs by 16.7 percent.

III. METHODOLOGY

i. Location and Orientation

The pond selected for installing floating solar photovoltaic power plant is located in Khurana, Haryana with a latitude of 29.857973N and longitude of 76.414772E, and an altitude of about 233 m above sea level. The pond is 62 m \times 62 m in size, and it covers an area of around 3844 m² at a depth of about 3 m. The space chosen for the PV plant is 22 m \times 27 m, giving it an area of roughly 594 m². Fig 1 shows the aerial view of location. Also, for overland solar photovoltaic power selected area is at Khurana, Haryana.



Fig.3.1: Aerial View of the Location (Google Earth Pro)

ii Technology Selected

a. Solar Module

For this project, a RenewSys India Pvt. Ltd. (DESERV 3M6-335) Multi Crystalline Silicon Modules has been selected. It has 72 cells, an efficiency of 17.33%, a rated power of 249.31 Wp at nominal operating cell temperature (NOCT), and 335 Wp under standard test conditions. The table below show solar module details.

Table 1: Technical details of selected module

Ratings at Standard Test Condition (1000 W/m ² , AM 1.5, 25°C)		
Nominal Values	DESERV 3M6-335 (Wp)	
Rated Power	P_{max} (Wp)	335
Maximum Power Voltage	V_{mp} (V)	37.9
Maximum Power Current	I_{mp} (A)	08.85
Open Circuit Voltage	V_{oc} (V)	46.27
Short Circuit Current	I_{sc} (A)	09.41
Module Efficiency	η (%)	17.33
Ratings at NOCT (Cell temp 45°C, 800 W/m ² , AM 1.5, 1 m/s wind speed)		
Rated Power	P_{max} (Wp)	249.31
Maximum Power Voltage	V_{mp} (V)	34.66
Maximum Power Current	I_{mp} (A)	07.20
Open Circuit Voltage	V_{oc} (V)	43.02
Short Circuit Current	I_{sc} (A)	07.69

b. Solar Inverter

The inverter use for this project is manufacture by Sungrow Power Supply Co.Ltd. The inverter having model is SG50CX. The rated input power of the inverter is 50 kW. Inverter having MPPT tracker are 5 Nos. With an efficiency of 98.7 %. Detail Information about inverter is given in below Table.

Table 2: Technical details of selected inverter

Input (DC)	SG50CX
Maximum PV input voltage	1100 V
Minimum PV input voltage	200 V
Nominal PV input voltage	585 V
MPP voltage range	200-1000 V
MPP voltage range for nominal power	550-850 V
No. of independent MPP input	5
Max. number of PV string per MPPT	2
Max. PV input current	130 A
Max. current for input connector	30 A
Max. DC short-circuit current	200 A
Output DC	SG50CX
AC output power	55kVA at 40°C / 50 kVA at 45° C
Max. AC output current	83.6 A
AC voltage range	312-528 V
Nominal grid frequency	50 Hz
THD	< 3%
Power factor at nominal power	>0.99
Feed in phases	3
Maximum efficiency	98.7

iii) Economic Analysis**a. Net Present Value (NPV)**

The simplest discounted cash flow metric of project worth is the Net Present Value. By deducting the total discounted current value of the cost stream from that of the benefit stream, the net present value (NPV) may be calculated. The formula provided can be used to compute the NPV.

$$NPV = \sum_{t=1}^n \frac{B_t - C_t}{(1+i)^t}$$

Where,

C_t = Cost in each year

B_t = Benefit in each year

$t = 1, 2, 3, \dots, n$ (years)

i = Discount rate,

b. Return on Investment

$$ROI = \frac{\text{Net profit}}{\text{Total Investment}}$$

c. Payback period

$$\text{Payback Period} = \frac{\text{Total Cost of Investment}}{\text{Yearly Saving}}$$

iv Metrological Data

The metrological data used in the research project was obtained from Meteoronorm 8.0 for the Khurana, Haryana location. In Table 3 monthly values for horizontal global irradiance, horizontal diffuse irradiance, ambient temperature, and wind speed are shown.

Table 3: Monthly Meteorological Value for Location Khurana, Haryana (Meteonorm 8.0).

Values	Horizontal Global Irradiance (kWh/m ²)	Horizontal Diffuse Irradiance (kWh/m ²)	Temperature (°C)	Wind Velocity (m/s)
Month				
January	94.9	46.9	11.7	0.69
February	110.8	53.9	15.7	0.89
March	158.7	71.3	21.5	0.91
April	166.8	84.8	27.4	0.99
May	190.3	104.8	32	0.99
June	174	104.4	31.8	0.9
July	163.3	103.9	30.7	0.8
August	151.3	92.8	29.8	0.59
September	151.6	73.2	28	0.6
October	131.5	70.9	24.8	0.38
November	103.5	51.8	18.6	0.41
December	88.4	46.1	13.4	0.51

IV. EXPERIMENTAL RESULTS

I. COMPARISON FOR ELECTRICITY GENERATION.

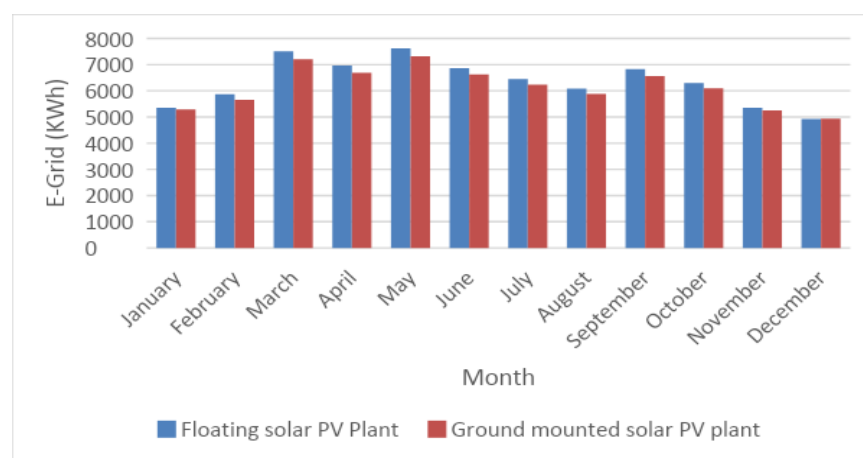
**Fig 3.2: Monthly Electricity generated for FSPV and Overland solar PV power plant.**

Fig 3.1 shows the variation in electricity generation by Floating solar photovoltaic power plant and overland solar photovoltaic power plant. The annual energy injected to grid by FSPV plant is 76129 KWh and by overland solar

photovoltaic power plant is 73751 KWh. The FSPV plant generate energy annually by 3.12 % more than the overland solar PV plant. This is because of reduction in module temperature of FPV plant due to the cooling effect of water.

II. Comparison for performance ratio

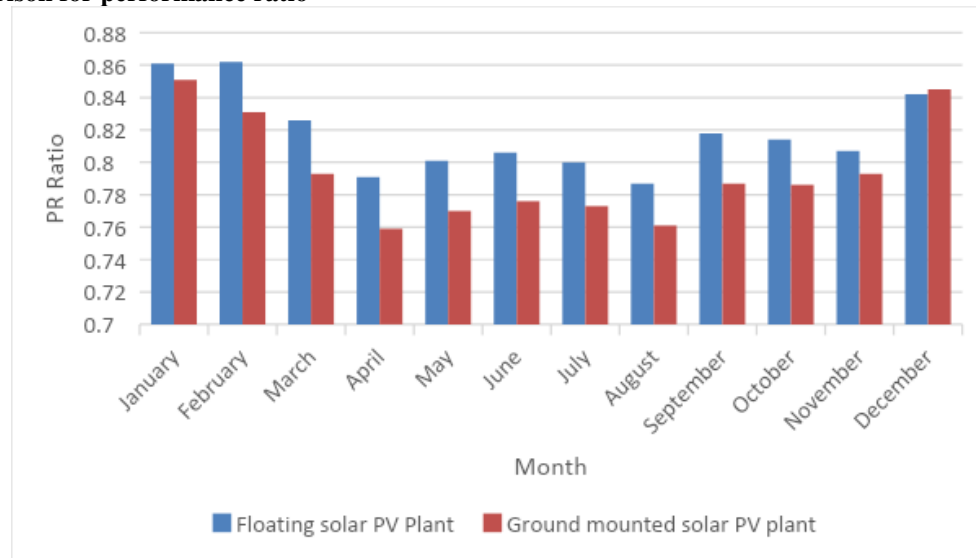


Fig 3.3: Monthly Performance Ratio for FSPV and Overland solar PV power plant.

Fig. 3.2 shows the monthly performance ratio for FSPV and Overland solar PV power plant. The annual performance ratio for FSPV and overland solar PV plant is 0.816 and 0.790. So, it is found that FSPV plant has more performance ratio than the overland solar photovoltaic power plant.

Economic analysis of Floating solar Photovoltaic power plant and Overland solar Photovoltaic power plant

Economic analysis of Floating solar photovoltaic power plant and overland solar photovoltaic power plant. For the FSPV system the total energy production of taken from the PVsyst simulation result was 76.1 MWh/year, and the LCOE obtained is 2.454 ₹/KWh. The lifetime of the projects was considered 25 years. Based on that the payback period (PBP) is coming out to be 5.2 years with an attractive ROI of 335.5 % and NPV of 7113293 ₹. Also, for the overland solar photovoltaic power plant, the total energy production was 73.8 MWh/year, and the LCOE obtained is 2.481 ₹/KWh. The lifetime of the projects was considered 25 years. Payback period (PBP) is coming out to be 5.2 years with an attractive ROI of 347.5 % and NPV of 6046356 ₹. It is found that cost of installation of FSPV increases due to need of floating platform on the water body. The capital cost of FSPV is about 17.48% higher than Overland Solar power plant.

V. CONCLUSION

Khurna, Haryana is considered for the study and energy calculations are performed for 50 KW Overland Solar power plant and 50 KW FSPV solar power plants. The global horizontal radiation for Khurana, Haryana is estimated as 1685.1 KWh/m². The annual global radiation on inclined surface is calculated to be 1832.6 KWh/m². 50 KW overland solar power plant at Haryana can generate 73.751 MWh annually. 50 KW FSPV power plant at Haryana can generate 76.129 KWh annually. The annual performance ratio for SPV and FSPV is 0.790 and 0.816 respectively. The FSPV plant generate energy annually by 3.12 % more than the overland solar PV plant. This is because of reduction in module temperature of FSPV plant due to the cooling effect of water. It is found that cost of installation of FSPV increases due to need of floating platform on the water body. The capital cost of FSPV is about 17.48% higher than Overland Solar power plant. However, the benefits of saving water and higher efficiency over its lifespan will make FSPV financially also superior to Overland Solar Power plant.

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