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Comparison between Floating Solar PV Plant and Grounded PV Plant at Bhimtal

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***Abstract*: Floating solar power plant is an innovative approach of using PV modules on water infrastructures to conserve the land along with increase in efficiency of the module. Additionally, the water is also conserved due to reduction in evaporation of water from the water body. The plant can be installed on a pond, lake, reservoir, or on any other water body. In this paper, a comparison is done between the floating solar PV system and the grounded solar PV system at bhimtal. Energy that could be produced by the two plants along with amount of water saved from evaporation and reduction in CO2 emissions are also calculated in this paper.**

***Keywords*: CO2 emission reduction, floating PV system, PV Watts, solar energy, temperature**

1. Introduction

An understanding of the future of land is required to inform policy on sustainable development. Land is a limited resource that provides food, fibre, shelter and important ecosystem services to humanity. As a key element in attaining many global ambitions for sustainable development, policymakers require insight into what future land use might look like and how this affects the ability of land system to continue supplying ecosystem goods and services. So there is a greater need of land for many purpose and as land has become very expensive and important part of everybody life so we need to make use of other resources. Solar energy can be utilized for power generation in numerous ways. One of the barriers in harnessing solar energy is large land requirement. This problem can be addressed by using Floating PV (FPV) system. Floating PV system is an innovative and new approach of installing PV modules on water bodies. By installing FPV system, evaporation of water from water bodies can be reduced to 70% [3] and power gain is increased by 5.93% due to back water cooling of PV modules [2].

Floating Photovoltaic (FPV) power plant is the installation of solar PV modules on water bodies. FPV power plant has numerous advantages over SPV plants. Some of them are: i) Higher electrical energy generation due to low module temperature; ii) Reduction in water evaporation from the water body and thereby conserving valuable potable water; iii) No land requirement for installing the power plant as FPV system floats on the water; and iv) Though cost of installation of FPV increases due to need of floating platform on the water body, but there will be reduction in the length of power transmission lines as water bodies such as ponds are always close to inhabited areas. The main components required in FPV system are: i) PV system; ii) Floating structure; iii) Mooring system and buoyancy anchors; and iv) Underground cables [4].

In this paper comparison is done on the basis of difference between the performance of floating based solar PV system and grounded solar PV system by taking the following parameters:

- Temperature difference.
- Reduction in CO2 emission.
- Amount of water saved by reduction in evaporation.
- PV watt calculations.

2. Geographical location

A. *Subsection*

Bhimtal is a town and nagar panchayat in Nainital district in the state of Uttarakhand, India, situated at an altitude of 1370 meters above sea level and is about 22 kilometers from Nainital. The major attraction in Bhimtal is the Bhimtal Lake, which has an island at its centre. Fig. 1, shows the Bhimtal lake in nainital district of Uttarakhand.

Bhimtal geographical location is, Latitude 29^0, 20', Longitude – 79^0, 33'.

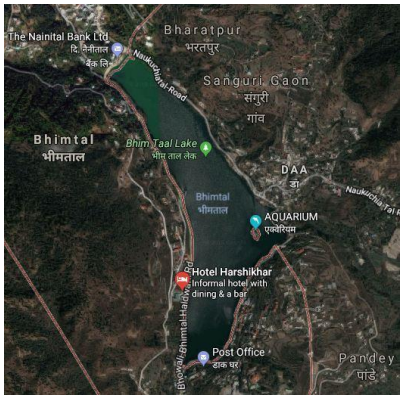

Fig. 1. Bhimtal geographical location

It is the largest lake in Kumaon region, known as the "lake district of India. The lake supports aquaculture with variety of fish species and provides drinking water supply. There is an island at the centre of lake which has been developed as a tourist spot and has an aquarium.

For installing the solar PV plant the Uttarakhand government is also providing subsidy. Uttarakhand has multiple micro climate zone. Uttarakhand is richly gifted with the natural renewable resources for generating electricity. The government of Uttarakhand wants to promote the harnessing of solar energy in the state.

As of 2011 India census, Bhimtal had a population of 7722, a 31.46% increase in population compared to 2001.Being a tourists place Bhimtal requires ornamental lightning during night periods for which solar powered battery storage can be used around the lake. The lake is surrounded by hotels and restaurant which requires energy so a floating PV plant can make them energy independent.

3. Methodology

Annual solar radiation at Bhimtal lake is 5.61 kWh/m^2/day. 8.3 kW conventional PV plant at Bhimtal lake could produce 12,291 kWh/year valuing 61,064/year as per current rates of electricity tariff of 4-5/kWh. Fig. 2, shows the monthly generation of AC energy and Fig. 3, shows monthly amount saved from 8 kW floating PV plant at Bhimtal as predicted by PV Watts calculator. AC energy yield will be highest in the month of March and lowest in the month of September. Amount saved indicates cost saving, if the same amount of energy as produced by the floating PV plant is otherwise purchased from the grid.

For 8.3 kW floating plant, area required would be about 50 m^2 and covering this area over water body would annually save about 1.85 lakh litres of water from evaporation. 8.3 KW floating PV plant at Bhimtal Lake could reduce 14.44 tonnes of CO2 emissions annually.

In addition, the higher intensity of the solar radiation can help out to increase generation efficiency of the PV cells, and so same for higher wind speeds. Although the solar radiation and the wind speed remained stable in simulation, the changes in the practical wind and solar conditions should be measured in the practical design of the floating PV systems in order to reach the higher generation efficiency.

A. Solar radiation at Bhimtal

Annual global horizontal radiation for Bhimtal in India, is calculated to be 1.98 MWh/m^2 from per day NASA data. The tilt angle is considered same as latitude of Bhimtal. The annual global radiation on inclined surface is calculated to be 2.1 MWh/m^2. Fig. 3 shows the monthly variation of global horizontal radiation and global radiation on inclined surface at Bhimtal in India [1].

B. Data collection

Energy saving calculations: PV Watts calculator developed by (NREL) National Renewable Energy Laboratory was used for estimating the energy yield of 8.3 kW floating PV plant at Bhimtal lake. Graphs were plotted based on the results obtained.

Water saving calculations: It is assumed that 8.3 kW floating PV system would require an area of around 10 m^2. Also considering that 1000 gallons/m2/year of water would be saved due to reduction in evaporation, the annual water savings from the 8.3 kW floating PV plant at Bhimtal Lake has been calculated respectively.

Calculation for reduction in CO2 emissions: Considering 0.932 tones of CO2 emission reduction per megawatt-hour of energy produced from solar PV plants , CO2 emissions reduced by 8.3 kW floating PV plant at the site under study were calculated [16].

The operating temperature has a major impact on efficiency of the PV modules and the decrement in the operating temperature tends to increase the module efficiency. Therefore, comparing with terrestrial PV systems, a floating PV system may profit from cooling effect of the water and operate with a superior efficiency, since it is installed close to water surface. In order to examine cooling effect of the water on the PV modules, a 3-D finite element analysis was in use to study temperature of the PV cells. The results were then used to compute the changes in power generation efficiency. This study also broadly studied potential of the floating PV systems in terms of the conservation of water and the land resources [14].

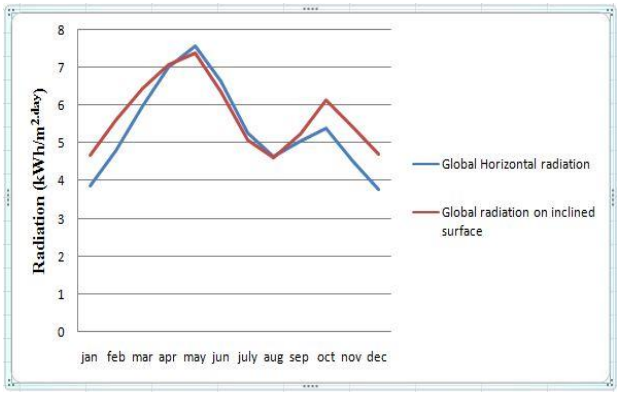

Fig. 2. Monthly variation of global horizontal radiation and global radiation on inclined surface at Bhimtal

C. PV Watts calculation

12,290 kWh per year of energy is obtained [3].

AC energy generated:

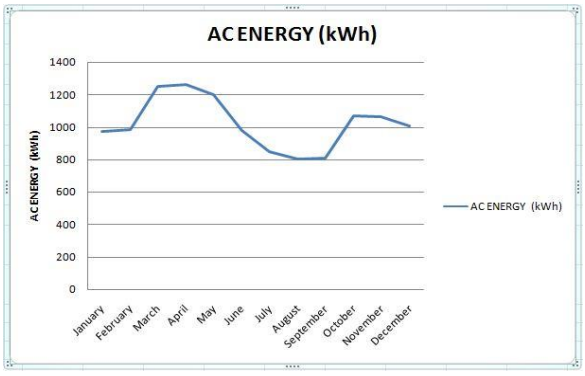

Fig. 3. AC energy generated from 8.3kW FPV plant at Bhimtal Lake

Amount saved:

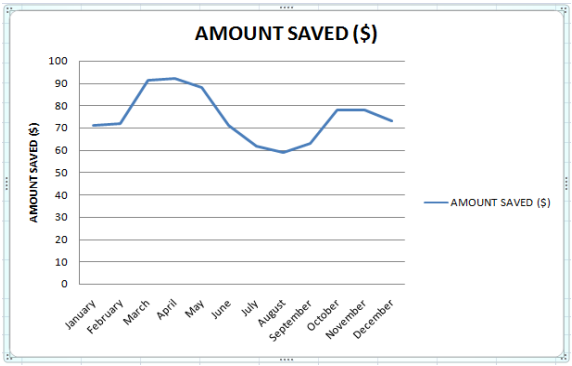

Fig. 4. Monthly amount saved from 8.3 kW FPV plant at Bhimtal Lake

D. Cost comparison

For grounded solar PV plant

This includes the cost of the land of area 50 m2 that costs around Rs. 1000 per month

For the span of 25 years

Total cost = 25 * 1000 * 12 =3, 00,000

For floating solar PV plant

There is one time cost investment in the floating pontoon structure.

This includes the onetime cost investment of the floating ponton structure that cost around Rs. 1,50,000 for the span of 25 years.

Cost Saving

For the land of area of 50 m2 the cost saving for the span of 25 years will be equal to:

Cost Saving = Rs. (3,00,000 – 1,50,000)

= Rs. 1,50,000

4. Conclusion

1. The optimal design of solar power plant can be done on Bhimtal Lake, Uttarakhand. A cost comparison of floating solar PV plant with conventional PV plant is done on the Bhimtal Lake for the land area of 50 m^2 which saves Rs.1.5 lakh for the span of 25 years.
2. Due to cooling effect of the water, average ambient temperature on the water is about 5 ^oC lower than that on the land with all other conditions being same. This paper recognized a finite element model and found that a (3.5–5) ^oC difference in the operating temperature between floating PV cell and a conventional PV cell [15].
3. 8.3 KW FPV power plant at Bhimtal can generate 12,567.54 kWh annually. The annual average module temperature is estimated to be 29.35^oC. 191.174 million litres of water annually will be saved from being evaporated and can reduce about 14.44 tonnes of CO2 emissions annually. It is a considerable amount of potable water.

FPV system is found to have 2.25% increment in annual energy generation with 14.29% decrement in module temperature. Also, the amount of water saved by covering the water surface by installing FPV shows that the FPV plant is more beneficial than SPV plant. More energy generation and considerable saving of potable water and non-requirement of land area for establishing the power plant makes FPV systems superior to SPV systems.

Table 1
Comparison of 8.3 kW SPV & 8.3 kW FPV power plants at Bhimtal lake

Parameter	8.3 kW SPV	8.3 kW FPV
Annual energy supplied to the grid (kWh)	12,291	12,567
Reduction in CO_2 Emission annually(In tonnes)	0	14.44
Average Module Temperature (^oC)	34.35	29.35
Amount of water saved from evaporation annually (lakh litres)	0	1.85

5. Future scope

Further a detailed analysis can be done with the help of more data's and make floating solar PV plant more cost effective. The outcome of the thesis can be proposed to the government for the benefit of the common people in the cost effective land of mountainous region of the Uttarakhand where the lakes are situated.

Further the use of FPV can also benefit the plains areas of Rajasthan and other cities where there is a problem of water scarcity, which can benefit the cities in terms of power need also.

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