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Electricity Generation of Solar Photovoltaic System

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Abstract: The SPV electricity generation employs various cell technologies namely polycrystalline, mono crystalline, amorphous, CIGS cells. To evaluate the performance of SPV plant a mathematical model was generated base on empirical relations and performance was calculated under various conditions. The electrical output was calculated based on various parameters such as tilt angle, cell technology, radiation levels. Sensitivity analysis was also carried out at five different geographical locations namely New Delhi, Ladhak, Jodhpur Mumbai, and Bangalore. The result shows that electrical output is maximum for polycrystalline cell at a give location and at tilt angle of plus minus 5^0 of location. Jodhpur was found to be the best geographical local followed by New Delhi.

Keywords: *Solar photovoltaic system, Tilt angles, amorphous, mono crystalline, polycrystalline, Sensitivity analysis.*

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I. INTRODUCTION

Sustainable development is the development which meets the needs (energy, food etc.) of the present without compromising the ability of future generations to meet their own needs. Sustainable energy systems can be defined as those systems that can provide energy services to the present generation while ensuring that similar levels of energy services can be provided for future generations. The present fossil based electricity generation systems are not sustainable source of electricity generation [1]. Due to limited fossil fuel resources, these systems will not be able to deliver electricity (at affordable rates) in future [2].

It is clear that present fossil fuel-driven energy systems are unsustainable in nature due to the finite fossil fuel reserves and the environmental impacts associated with these systems [3]. It is therefore important to find a sustainable solution in the energy (electricity) sector and at the same time meet the increasing demand generated by the growing economy [4]. Renewable energy sources like solar, biomass, small hydro etc. can contribute to build up a more sustainable energy system [5] in countries like India. Thereby, solar photovoltaic electricity generating systems can be used as a source of power generation which may be sustainable in terms of environment and economics [6]. The sustainability indicators evaluated for energy, environment and economics is electrical output.

II. MET HODOLOGY

India has a potential for renewable energy, as it has different climatic conditions (like rainfall, humidity, temperature, etc.) across its parts [7]. Thus, based on the different climatic conditions, the country may be divided into numerous climatic zones [8]. In this study, the different considered zones are, hot and dry (Jodhpur), warm and humid (Mumbai), moderate (Bangalore), cold and cloudy (Ladhak) and composite (New Delhi).

The performance of solar photovoltaic electricity generating systems is highly influenced by climatic conditions and its angle of tilt with the horizontal. This is because of the fact that both the climatic condition and tilt angle change the solar reaching the surface of the solar system. Among the various kind of solar PV systems, amorphous, mono-crystalline, and poly-crystal-line are the commonly used [9]. Since India is divided in five different climatic zones so a city is selected from each climatic zone and in the present work electrical output from the plant is calculated for three different cell technologies namely amorphous, mono-crystalline and poly-crystalline, the tilt angle considered are β=15º, 25º, 35º and 45º and three different radiation levels i.e. are 4, 5 and 6 kWh/m^2/day are considered.

III. RESULTS AND DISCUSSION

3.1 Effect of tilt angle & others at location ϕ=28º

Figure 1 shows the results generated for electrical output for different tilt angles for amorphous, polycrystalline and monocrystalline cells at different radiation level of 4, 5, 6 kWh/m^2/day, with respect to at location ϕ=28º(New Delhi)

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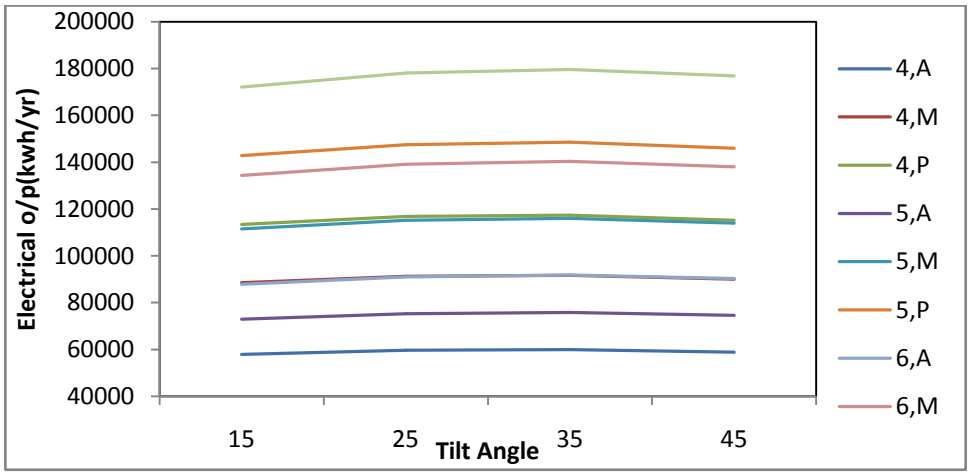

Figure 1. Effect of tilt angle, type of cell and radiation level on electrical output (kWh/year) for location with $\phi=28^0$.

3.2 Effect of tilt angle & others at location $\phi=18^o$

Results were investigated for effect of variation on electrical output for different types of cells, at different tilt angle of module and at different radiation levels of H_g of 4, 5, 6 kWh/m^2/day, at various tilt angles at location $\phi=18^o$. This is shown in consolidated form in Figure 2

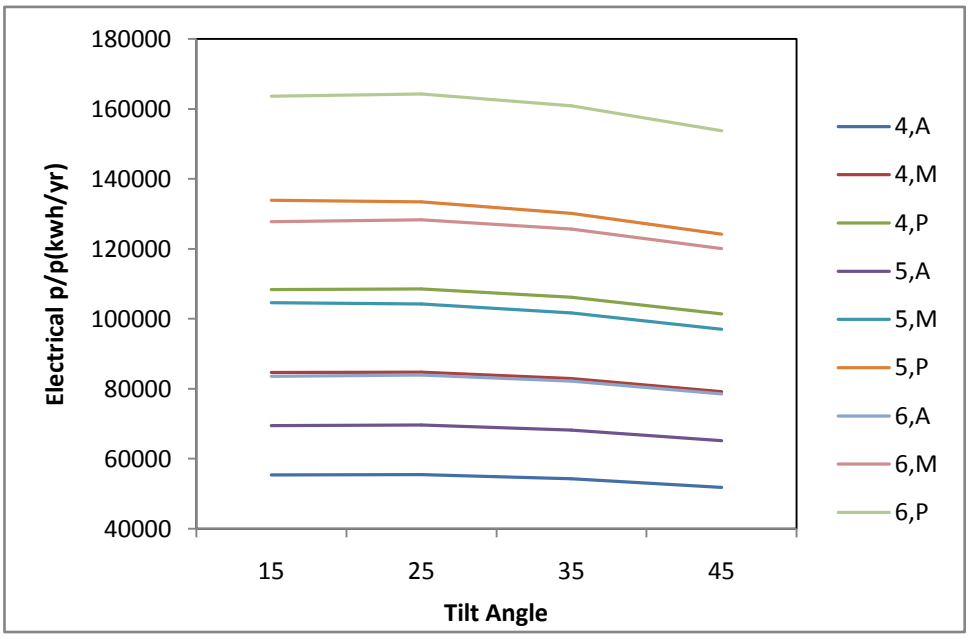

Figure 2: Effect of tilt angle, type of cell and radiation level on electrical output(kWh/year) for $\phi=18^0$.

3.3 Effect of tilt angle & others at location $\phi=12^o$

Results were obtained showing variation of electrical output for different types of cells, and radiation level H_g of 4, 5, 6 kWh/m^2/day, with respect to tilt angle at location $\phi=12^o$. This is shown in consolidated form in Figure 3.

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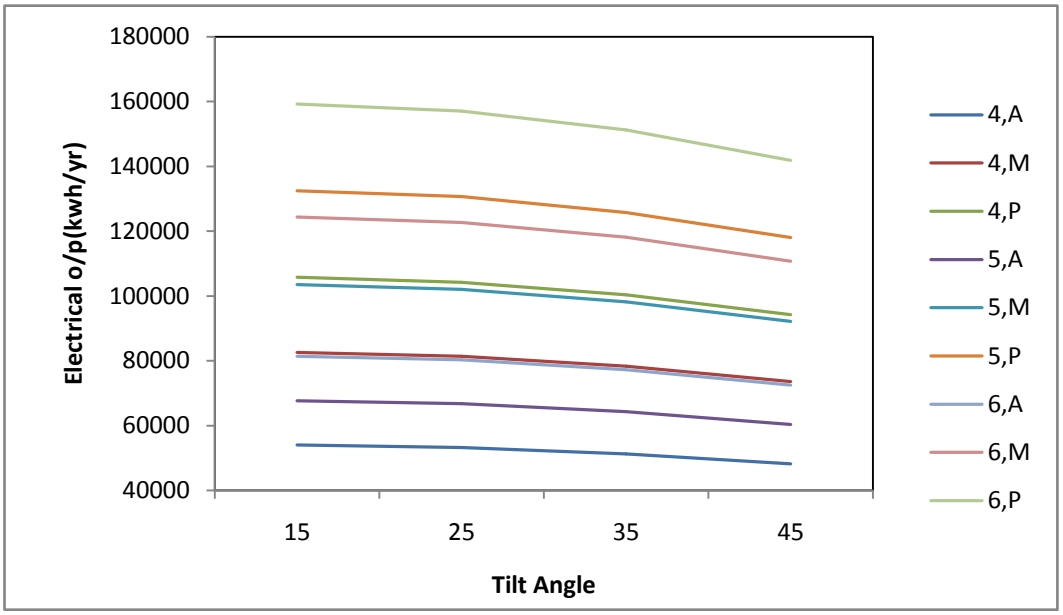

Figure 3: Effect of tilt angle, type of cell and radiation level on electrical output(kWh/year) for $\phi=12^0$.

3.4 Effect of tilt angle & others at location ϕ=34º

Results were obtained showing variation of electrical output for different types of cells, and radiation level H_g of 4, 5, 6 kWh/m^2/day, with respect to tilt angle at location ϕ=34º. This is shown in consolidated form in Figure 4.

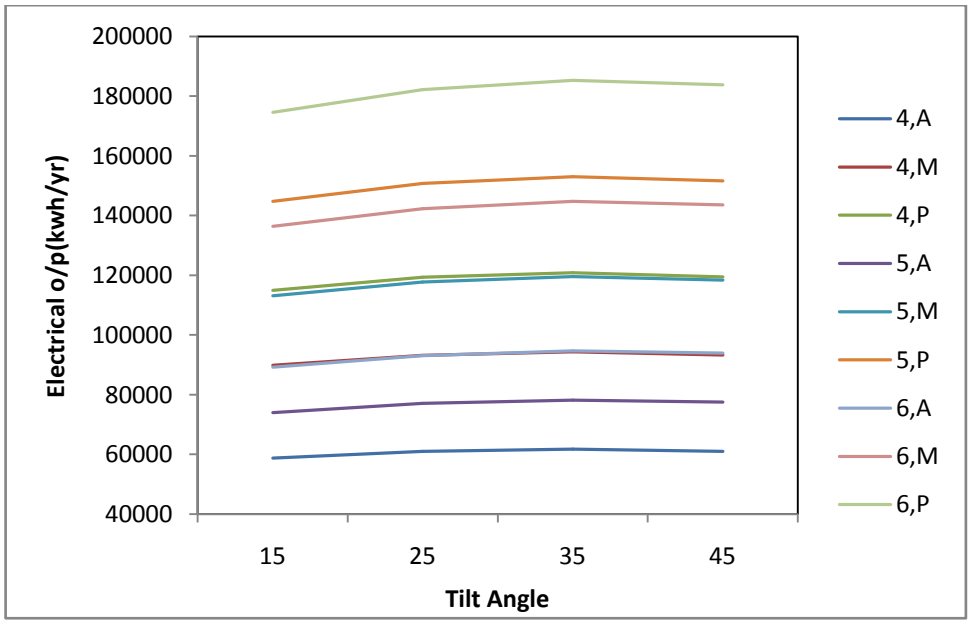

Figure 4: Effect of tilt angle, type of cell and radiation level on electrical output(kWh/year) for $\phi=34^0$.

3.5 Effect of tilt angle & others at location ϕ=26º

Results were obtained showing variation of electrical output for different types of cells, and radiation level H_g of 4, 5, 6 kWh/m^2/day, with respect to tilt angle at location ϕ=26º. This is shown in consolidated form in Figure 5 .

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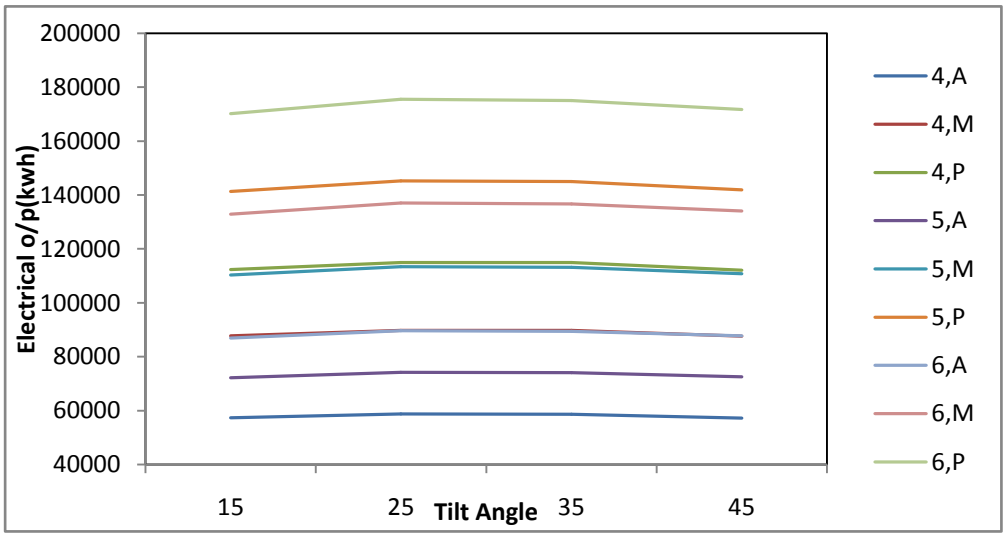

Figure 5: Effect of tilt angle, type of cell and radiation level on electrical output (kWh/year) for $\phi=26^0$.

Table 1: Results generated for maximum electrical output (kWh/year) for amorphous cell at different locations(ϕ), tilt angle, and different radiation level.

ϕ	β	Cell Type	Electrical Output (Hg=4)	Electrical Output (Hg=5)	Electrical Output (Hg=6)
28	35	Amorphous	59990	75896	91802
18	25		55452	69692	83931
12	15		54043	67707	81372
34	35		61742	78233	94723
26	25		58758	74216	89702

Table 2: Results generated for maximum electrical output (kWh/year) for monocrystalline cell at different locations(ϕ), tilt angle, and different radiation level.

ϕ	β	Cell Type	Electrical Output (Hg=4)	Electrical Output (Hg=5)	Electrical Output (Hg=6)
28	35	Monocrystalline	91700	116013	140327
18	25		84763	104228	128295
12	15		82608	103496	124383
34	35		94738	119584	144791
26	25		89817	113445	137117

Table 3: Results generated for maximum electrical output (kWh/year) for polycrystalline cell at different locations(ϕ), tilt angle, and different radiation level.

ϕ	β	Cell Type	Electrical Output (Hg=4)	Electrical Output (Hg=5)	Electrical Output (Hg=6)
28	35	Polycrystalline	117410	148541	179671
18	25		108528	133451	164266
12	15		105770	132513	159257
34	35		120839	153113	185386

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26	25		114999	145253	175561

IV. Conclusion

Three cell technologies polycrystalline, monocrystalline and amorphous were compared based on electrical output from the plant based on specific technology. It was found that the output was maximum in the case of polycrystalline cell i.e. 185386 kWh/year for geographical location of $\phi=34^0$ and is minimum for 81372 kWh /year $\phi=12^0$ for amorphous cell ,at maximum insolation level of 6 kWh/m^2/day (table1).The sensitivity analysis carried out shows that the best geographical location for setting up of solar plant is jodhpur($\phi=34^0$) in India.It is also concluded that electrical output is maximum for a tilt angle plus minus 5º of latidude.

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