Effect on payback period and generation of 15 kW solar roof top systems by using poly-crystalline and mono-crystalline solar panels

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Abstract: Solar Energy is the most non exhaustible source of energy. World is going through a fuel crises due to rapidly diminishing the conventional stock. Hence it is necessary to install such a system which will give energy free of cost for a long period. Now a day the electrical energy is most demandable source of energy and whole word is suffering from the fuel crises. In such situation solar panels are playing vital role for generation of electrical energy. This paper describes the effectiveness of installation of poly crystalline and mono crystalline panels for generation of electrical power in 15kW solar power plant and its comparative study on the cost and power generation.

***Keywords*— Solar panels, Poly crystalline, Mono crystalline ACDB, DCDB**

I. INTRODUCTION

1. Introduction: Generation of electrical energy through solar energy source come into existence from the year 1884 with the efficiency of only 1% at new York. But after nearly 135 years later the power plant efficiency not more than 17% to 19 %. This shows the difficulties in research and production of efficient solar panels. Now a days solar panels are being produce in the range of 500Wp which will increase the power generation capacity per square meter area. There are many modules which came in existence like 60 cells, 72 cells. Another main innovation in the field of solar panels is the material that has been used for solar cell. Poly crystalline panels are made up of fragmentation of silicon to form wafers. Due to which this panel also referred as multi crystalline panels. Since there is less mobility to move number of electrons, the efficiency of this panel is less.

Mono crystalline panels are made up of single crystal silicon in which there are more mobility for electrons to move hence the efficiency of such panels are more as compared to polycrystalline panels. Moreover the dimensions area for these panels is nearly same. In this paper effect of payback period and generation of 15 kW solar roof top systems by using poly crystalline and mono crystalline panels are discussed.

2. Angle of sunrays on solar collector:

Point no. 8 plays an important role for deciding the and estimating the total radiation falling on solar panels and the angle of incidence of sunrays on the collector. In general practice the solar collectors are mounted perpendicular to sun rays. In order to collect maximum solar radiation, angle of incidence θ is to be define between the direct or beam of Sunrays and normal of the solar collectors. The current that would generated by collector will be given by

$$I = I_b \cos\theta \text{---------(i)}$$

Where $I_b$is the intensity of beam.
The angle θ depends on five different angles which are interrelated to the location of collector ,time of the year & orientation of the collector. These angles can be defined as 1. latitude of location ϕ 2. Days of year δ 3.Time of the day ω 4.Inclination of surfaceβ 5. Orientation of collector in horizontal plane γ.

The relationship between incidence angle & other angle can be given in the form of equation as

Cos θ = sinϕ (sinδcosβ + cosδcosγcosω sinβ) + cosϕ (cosδcosωcosβ- sinδcosγ sinβ) + cosδ sinγ sinω sinβ) ----------(ii)

When collector surface is lying on the ground horizontal plane becomes zero & hence $\beta=0^0$. This equation is useful to calculate the angles for tracking system. For deciding direction of rotation of the collector for different longitude & latitude own is shown in fig.1.

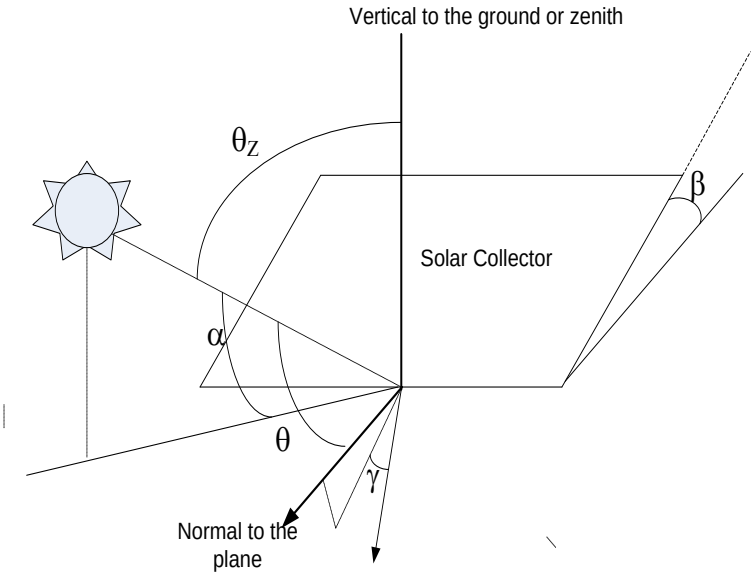

Fig.1Schematic representation of angles θ, γ, βα, θz

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Energy generated by solar panels is depends upon the type of mounting structure. The tracking system are mostly used where huge power generation are estimated, but for small power generation like in case of residential and commercial mostly fix type structure are used. Payback period is directly proportional to the amount of energy generated.

3. Optimal Angle for Fixed Collector Surface:

For optimum generation of PV solar energy the collector plates should be rotating to collect maximum harness sunlight. But it is not economical for everyone. So it is preferred to have a fix collector structure. In order to obtain maximum sunlight the collector should be fixed facing towards south if it is located at northern hemisphere, if it is in southern hemisphere, collector should facing toward north and optimal inclination of the surface would be given by

$$\beta = \phi - \delta \text{--------(iii)}$$

This equation is well known by the facts that collector surface should be perpendicular to the sunrays at noon time since radiation intensity is maximum at noon. In equation (iii) the declination angle δ changes every day. Therefore angle β of collector will also varies every day and it is not possible to change in practically. Hence average declination angle can be used and the equation (iii) becomes

$$\beta_a = \phi - \delta_a \text{--------(iv)}$$

Where

1. δ_a is average declination angle over a given period
2. β_a is the optimal inclination angle of the collector over the period.

Over the period of one year average declination angle is zero i.e$\delta_a = 0^0$. Thus the average inclination of collector over a period of year becomes

$$\beta_{ay} = \phi \text{ ----------(v)}$$

And the angle of incidence also changes to

$$\text{Cos } \theta = \cos\delta\cos\omega\text{----------(vi)}$$

The angle of collector directly effects the generation of solar energy. Poly crystalline panels or collectors generate some less power as compare mon crystalline collectors and hence small change in angle plays very important role in generation as well as payback period.

4. **Radiation of solar energy:**

Generation of solar energy is depends upon the amount of solar radiation collected by a collector at the particular location & the time. To measure the solar radiation pyranometer is used. But it is not economical to measure radiation every time for any location, hence it is recommended to use global radiation chart. Radiation of sun is effected by many parameters like number of sunshine hours, sky cleanness index, humidity etc. Since all this parameter differ from area to area it is unable to calculate standard any figure as a standard parameter.

The monthly average daily global radiation on horizontal surface Hga is given by equation (vii)

$$\frac{Hga}{Hoa} = \text{ a + b } \left(\frac{Sa}{Smaxa}\right)\text{---------- (vii)}$$

Where,

1. H_{oa} is monthly average extra terrestrial solar radiation.
2. S_a&$S_{maxa}$are the monthly average daily sunshine hours & maximum possible daily sunshine hours.

The value of a & b for New Delhi, India are 0.25 & 0.57 respectively & for Nagpur India the value of a & b are 0.27 & 0.50 respectively. For example a city like Nagpur 21.06 N 79.03 E for the month of march having the average sunshine hours per day is 9.2 the global radiation will be 22442.46 kJ/m^2 day as per equation (vii) [2]

Mono Crystalline and Poly Crystalline panels mainly affected by solar radiation. Specially mono crystalline panels are design to work for low light, hence it directly affects the generation of energy specially in the winter session.[3] [4]

$$Voc = \frac{mkT}{q} \ln\left(\frac{Isc}{Io} + 1\right)\text{-------(viii)}$$

Where

1. k is the Boltzmann constant,
2. T is temperature,
3. Isc is generated current,
4. q is charge of an electron and Io is the dark saturated current.

From the equation (viii), open circuit voltage generated is directly proportional to temperature, and temperature is directly proportional to radiation of light up to saturation point of silicon cell.

5. Effect of Air density and pollution on generation

Output current and open circuit voltage is directly proportional to the air presser i.e as the air presser increases it force to rises the solar intensity, those the parameters are interrelated but they are non linear in nature. [5]. Similarly the effect of pollution, i.e air west form company like power plant which contains mainly ash particles, Carbon particles stops intensity of light following on the light resulting the creating the abstract in the path of solar radiation falling on the ground. As per the equation (viii), voltage generation is directly proportional to the temperature results lower the output voltage. Performance of solar collector are measured in STC (Stander test Condition). i.e when solar irradiation is 1000 W/m^2, cell temperature is at 25^0C and air mass is 1.5 spectra. [6] Since mono crystalline panels are made up of pure silicon. They can generate more voltage as compares to poly crystalline panels.

6. Cost and comparison of mono and poly crystalline panels.

Payback period of any project depends on the cost of equipment that is used in project. Solar roof top project consist of mainly two part. 1) Electrical/Electronic part. 2) Mechanical part.

Electrical/Electronic part consist of Solar inverter, solar panels and AC distribution box, DC distribution box, AC cables and DC cable, Net meter and Generation meter (Optional). Whereas Mechanical part consist of solar structure, Earthing Material i.e. earthing rod etc., lighting arrestors (arrestor rod,) lighting and earthing strip or copper cable. Labor cost or installation cost.

Electrical cost of all electrical equipment is 70% of the project cost and total mechanical cost is 30% of the project cost. In any project mechanical cost may differ from 10% to 15% depending upon the type of project, location of project. For calculation purpose it can be formulated in mathematical model.

Total project cost = (A+B) ---------(ix)

Where

A= Cost of electrical equipment

B= Cost of Mechanical part

Payback period is that period in which invested amount get recover from the saving due to installation of project.

From the practical result it has been observed that mono crystalline solar panels generates more energy than poly crystalline panels. The graph shows the generation of mono vs. poly crystalline panels of 15 kW solar power plant.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Poly KWh output	1.98	2.025	2.07	2.277	2.25	2.16	1.83	1.8	1.04	1.35	1.44	1.65
Mono Kwh output	2.205	2.25	2.295	2.502	2.475	2.4	2.055	2.025	2.01	1.8	1.95	1.875

Table 1 Showing monthly output of Poly crystalline and mono crystalline solar panel for 15 KW solar plant

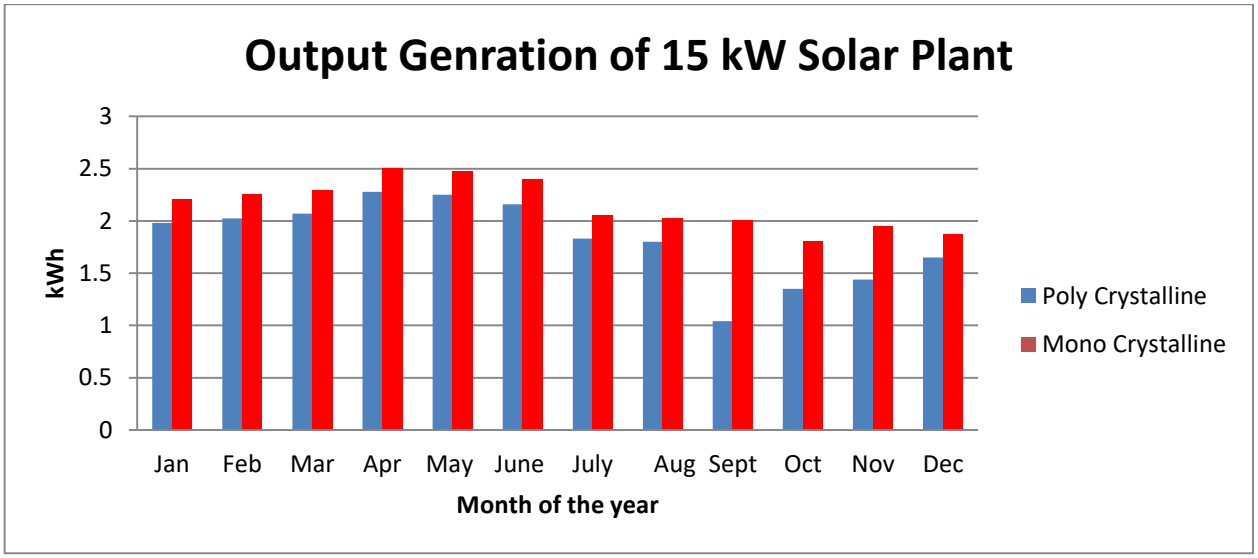

Fig. 2 Comparison between Poly Crystalline and Mono Crystalline panels for 15 kW Solar Plant

Power ratings of Mono Crystalline panels are more as compare to Poly Crystalline hence for same 15 kW power plant, no of panels required for Mono Crystalline are only 40no. while for poly it is 46no. of same size and same i.e 72cells. Hence cost of installation reduces. Similarly space required also reduces. In overall it can be said that mechanical structure and its cost get reduces. Cost of mono crystalline panels is more as compared to poly crystalline by nearly 10%. But this cost is get nullified by the reduction in no of panels and structure, installation cost of the plant.

7. Result and conclusion

Resulting all the reduction and more generation as compare to poly crystalline panels, payback period reduces 10% to 15% by using mono crystalline panels as compare to poly crystalline panels. Generation output of mono crystalline panels is also more in low temperature, especially in winter condition where ambient temperature is 25^0c and over all temperature is not more than 35^0c. Hence looking to over all performance it can be concluded that mono crystalline cells have good overall efficiency, more power output generation and less payback period.

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