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Research Paper

Performance Analysis of Crystalline Solar Panel.

[1]Ifeanyi.O.Ark, [2]Onuwabaghe Scott, [3]Anyim Charles.

[1, 2, 3.] Department of Electrical and Electronic Engineering, University of Benin, Benin City, Nigeria.

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Email: arkifeanyi@gmail.com

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Abstract: This paper is aimed at analyzing the performance of two different types of solar panels under similar and standard conditions. This analysis involves identification of a real life problem, and research on innovative, economic and efficient ways of solving this problem. The solar panel has various performance characteristics that may be simultaneously analyzed in order to obtain an optimum plan of what type of panel to select and how to install the selected panel. The efficiency of a solar panel, when analyzed, will help installers make the perfect choice in all aspects including types and installation techniques, hence, producing satisfaction from maximum utility of the equipment.

Keywords: Poly-crystalline Solar Panel; Mono-crystalline Solar Panel; Solar Energy; Electricity.

1. Introduction

The first generation solar panels are crystalline silicon solar cells. They are made from a single silicon crystal *(mono-crystalline*), or cut from a block of silicon that is made up of many crystals (multi-crystalline).The second generation panels are thin-film solar cells which are less expensive to produce compared to traditional silicon solar cells as they require a decreased amount of materials for construction. Just as the name implies, the thin-film PV cells are physically thin technologies that have been applied to photovoltaics. Monocrystalline silicon (or "single-crystal silicon", "single-crystal Si", "mono c-Si", or just Mono-Si) is the base material for silicon chips used in virtually all electronic equipment today.Mono-Si also serves as photovoltaic, light absorbing material in the manufacture of solar cells. It consists of silicon in which the crystal lattice of the entire solid is continuous, unbroken to its edges, and free of any grain boundaries. Mono-Si can be prepared intrinsically, consisting only of exceedingly pure silicon, or doped; containing very small quantities of other elements added to change its semiconducting properties. Most silicon mono crystals are grown by the Czochralski process into ingots of up to 2 meters in length and weighing several hundred kilograms. These cylinders are then sliced into thin wafers of a few hundred microns for further processing. It is no news that single-crystal silicon is perhaps the most important technological material of the last few decades. This has led to a silicon era due to its availability at an affordable cost and the development of the electronic devices on which the present day electronic and revolution in the information age is based. Monocrystalline silicon differs from other allotropic forms, such as the non-crystalline amorphous silicon used in thin-film solar cells, and polycrystalline silicon, that is made up of small crystals, also known as crystallites.

Polycrystalline silicon, also called poly-silicon or poly-Si, is a high purity, polycrystalline form of silicon, used as a raw material by photovoltaic and electronics industry. A thin-film solar cell *(TFSC),* also called a thin-film photovoltaic cell *(TFPV),* is a second generation solar cell that is made by depositing one or more thin layers, or thin film *(TF)* of photovoltaic material on a substrate, such as glass, plastic or metal. Thin-film solar cells are commercially used in several technologies including cadmium-telluride *(CdTe),* copper-indium-gallium-diselenide (*CIGS*), amorphous and other thin-film silicon (*a-Si, TF-Si*). Thin-film solar cells are cheaper than the crystalline silicon cell but less efficient than conventional crystalline silicon technology.

2. Problem Statement

Even in 21st century, there is still inadequate power supply in many countries across the world. This inadequacy in power supply has adversely affected the economic conditions of these countries, hence, the need for an alternative power source. Solar panels which serve as alternative power sources are costly for most people to buy and those who can afford them still encounter the problem of efficiency. Also there is the concern of which solar panel is more efficient and that which can adequately power the needed load. This paper discusses and analyses and determines the efficiency of polycrystalline solar panel in comparison with a monocrystalline solar panel using standard test conditions. The main objectives of this paper are

- To determine the output current and voltage of the solar panel for different time of the day.
- To get the graphical relationship between the output current and time, voltage and time.
- To calculate the efficiency of polycrystalline solar panel and compare it with the result of monocrystalline solar panel under similar conditions.

3. Methodology & scope of work

This project work covers the analysis of polycrystalline solar panel which involves using a multi-meter to measure the output current and voltage of the polycrystalline solar panel between the hours of 9am to 4pm for a period of three weeks and the results recorded. A comparison between the result of the monocrystalline solar panel and that of the polycrystalline solar panel will be made. The result obtained will be represented on a graph and this will be used to calculate the efficiency of the panel.

Significance of study: The importance of this project lies in the need for a clean, inexpensive and optimum use of reliable energy source. It also helps to provide an efficient and cost effective energy source for homes in developing nations. Furthermore, it also reduces the over-dependency on fossil fuel which leads to global warming. This work will also help in choosing which solar panel is best to install considering cost and efficiency.

Assumption and limitation: The project was carried out at the University of Benin, Benin City, Edo state, Nigeria. Hence, only the atmospheric conditions of this area will affect the result of the experiment. Other factors that are peculiar to other locations were not taken into consideration.

Experimental setup: The setup comprises two crystalline solar panels (monocrystalline and polycrystalline), two digital multi-meters for measuring voltage and current respectively, a microelectronic thermometer for measuring ambient temperature and the temperature of the panel. The system was installed at a height of four and a half feet from the ground.

Panel specifications

The specifications of the two panels are given below;

Polycrystalline Panel

Out Peak Power (Pm)	200W
Open Circuit Voltage (Voc)	45.48V
Short Circuit Current (Isc)	5.66A
Power Tolerance	5%
Max Power Voltage (Vmp)	37.89V
Max Power Current (Imp)	5.28A
Max System Voltage	1000VDC
Size of Module	1580mm x 808mm x 35mm

Monocrystalline panel

Max Power (+ 5%) [Pmax]	200W
Open Circuit Voltage (Voc)	42.0V
Short Circuit Current (Isc)	6.2A
Max Power Voltage (Vmp)	35V
Max Power Current (Imp)	5.7A
Size of Module	1500 × 830 × 35mm

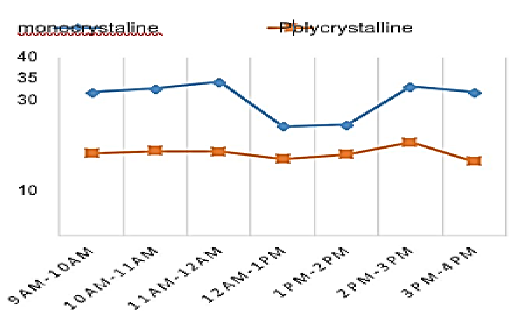
Experimental approach

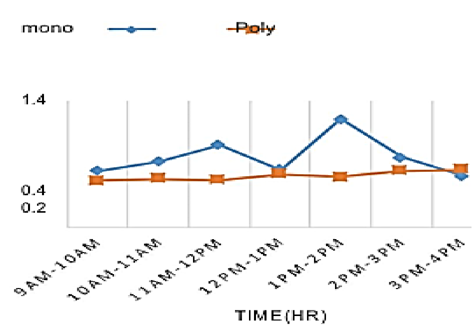
The test system was set up in an open field close to production *ELA* building, University of Benin, Ugbowo, Edo State. The experiment was carried out for a period of three weeks. It was done from the second and third week of May and the last set of experiment was carried out in the last week of July. The solar panel was oriented due south to a latitude of 6.4 degrees north. A microelectronic thermometer was used to take the ambient temperature and the temperature of the panel during the experiment. A digital ammeter connected in series was used to take the short circuit current and the maximum power point current. A voltmeter connected in parallel was used to take the open circuit voltage and the maximum power point voltage. For the first week, the solar panel was made to lie horizontally (with a tilt angle of 0 degrees) on a platform and the open circuit voltage, short circuit current, load current, load voltage and temperature were taken and recorded appropriately. For the second week, the solar panel was given a tilt angle of 15 degrees and was oriented due south. The open circuit voltage, short circuit current, load voltage, load current and temperature were taken hourly, from the hours of 9am to 4pm for four days of the week and the values were recorded. For the third week, the panel was given a tilt angle of 45 degrees due south and readings were recorded as before.

4. TESTS

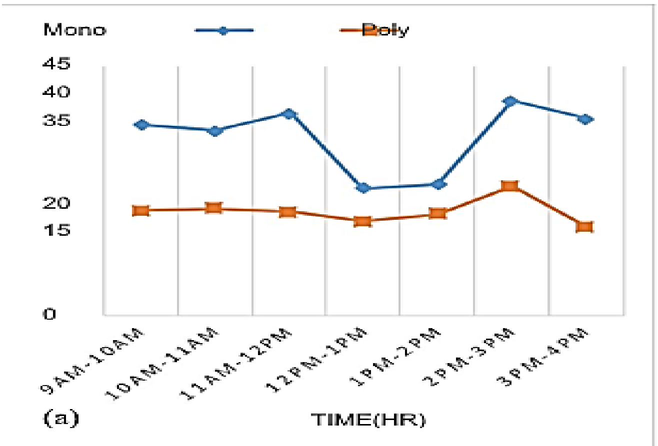
4.1. GRAPHS

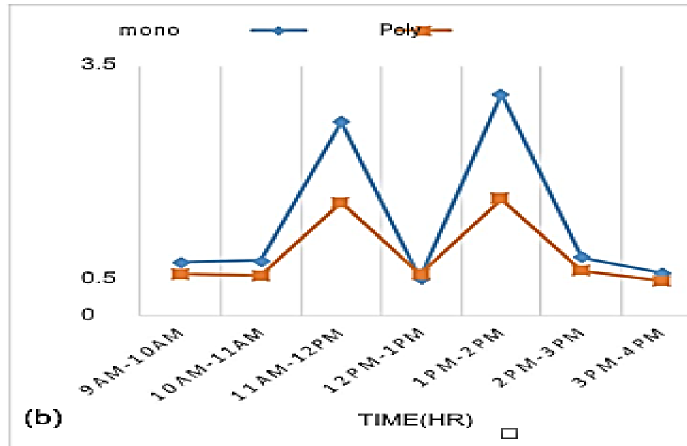
Day -1: 0 degrees tilt



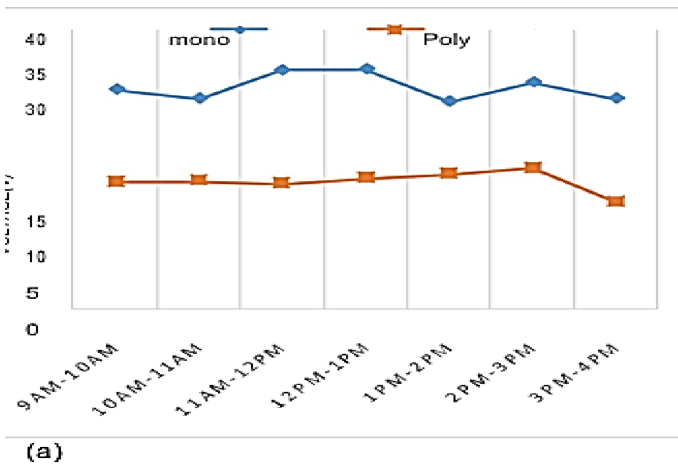


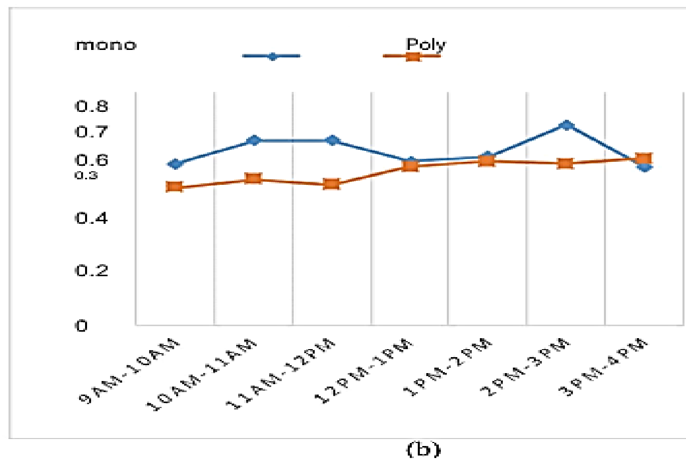
Day – 2: 0 degrees tilt



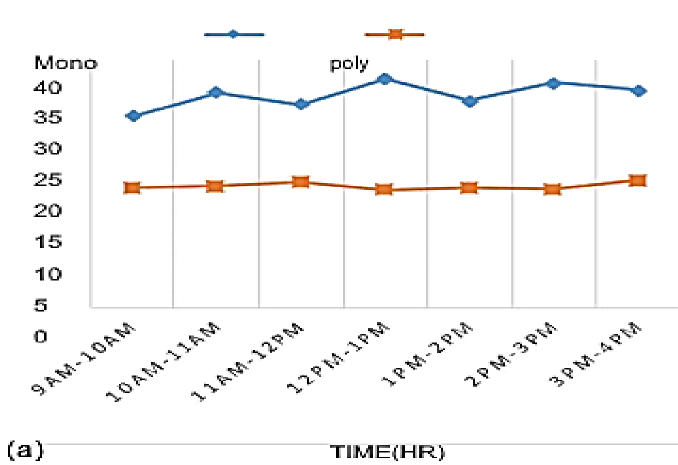


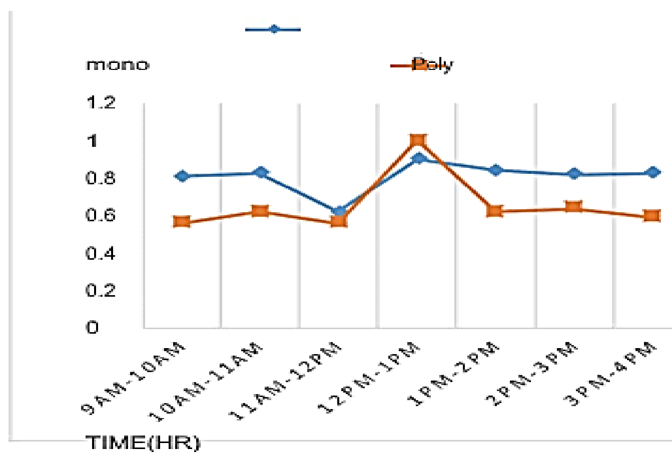
Day – 3: 0 degrees tilt



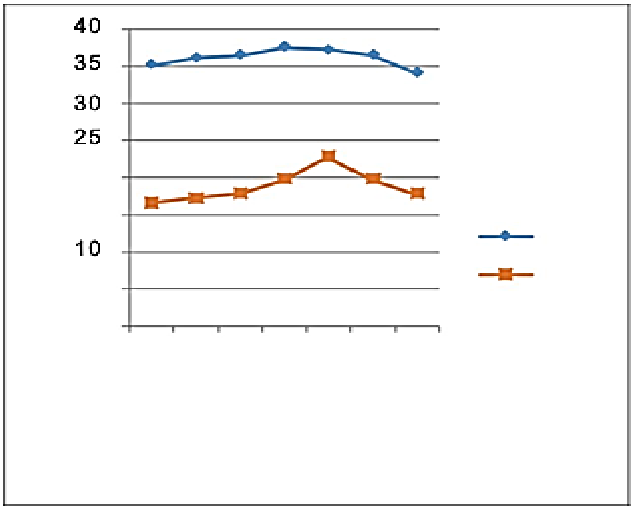


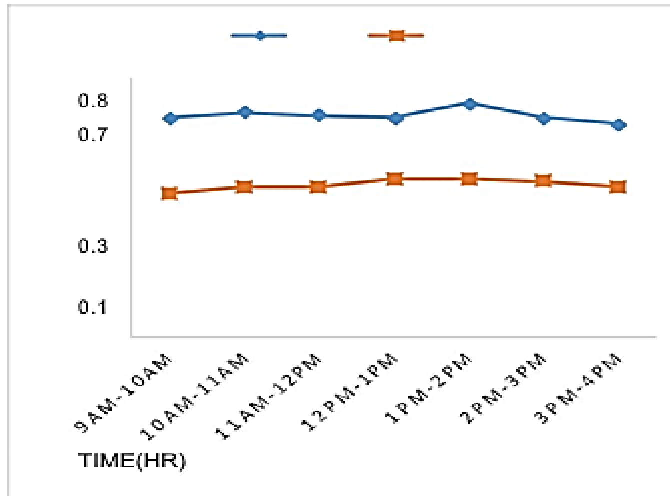
Day – 4: 0 degrees tilt



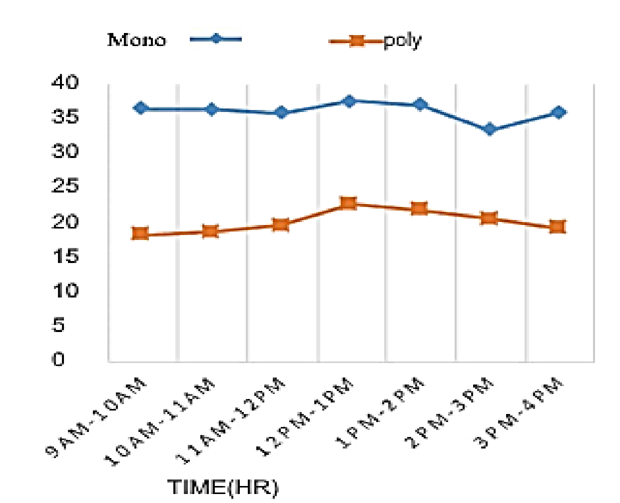


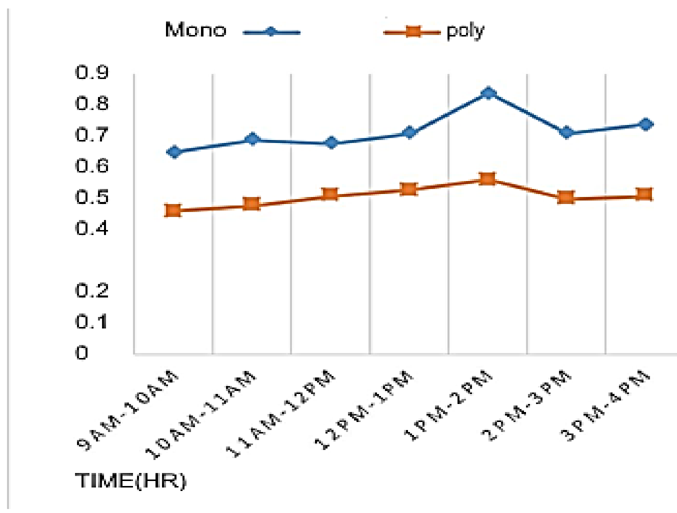
Day -1: 15 degrees tilt



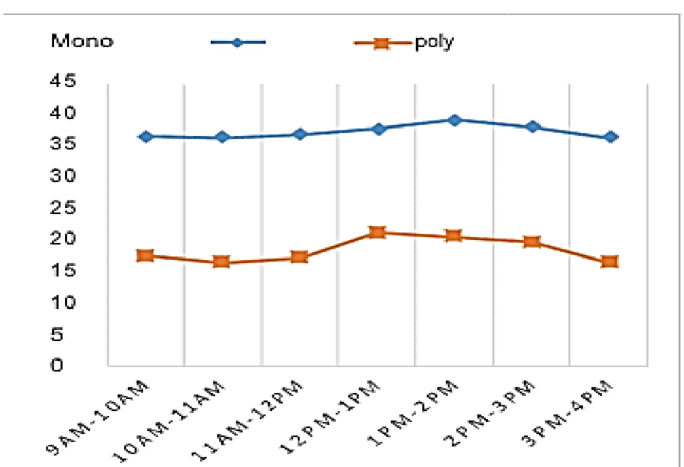


Day – 2: 15 degrees tilt

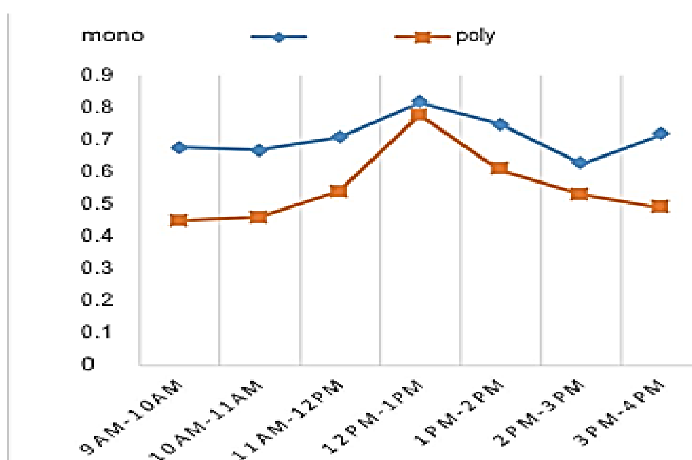




Day – 3: 15 degrees tilt

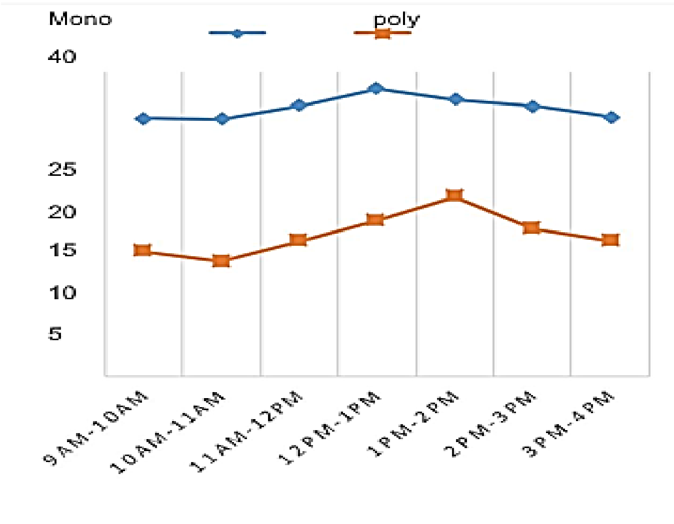


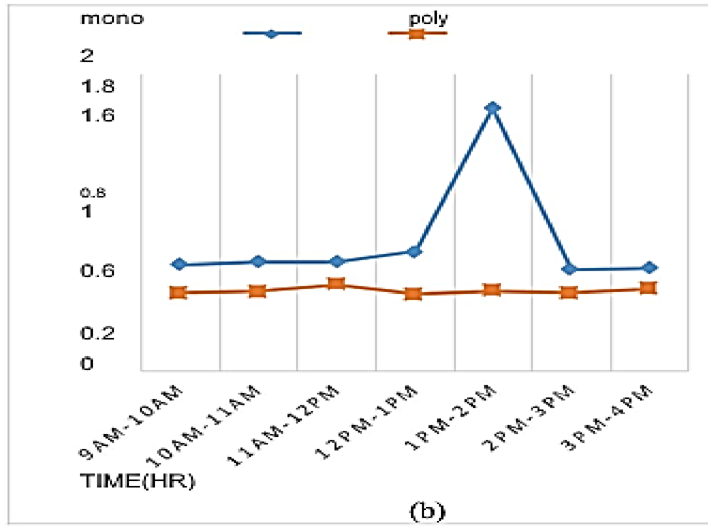
(a) TIME(HR)



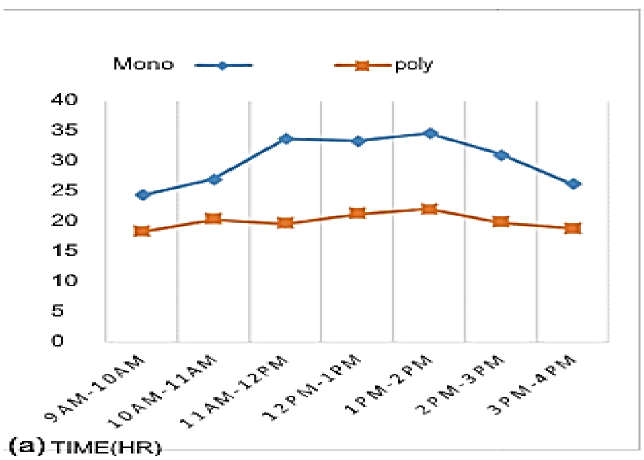
(b) TIME(HR)

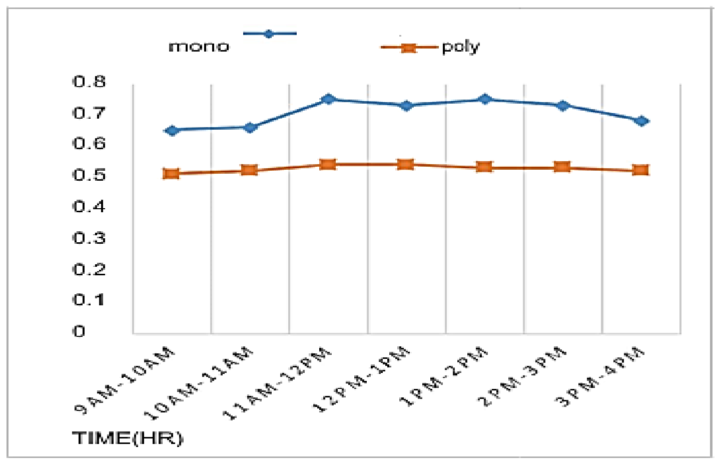
Day – 4: 15 degrees tilt



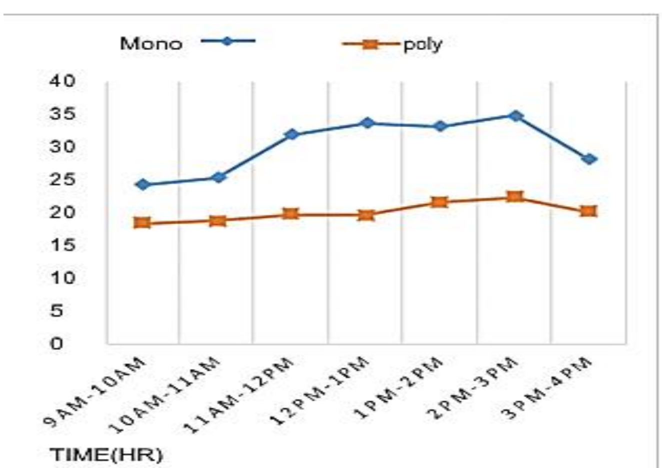


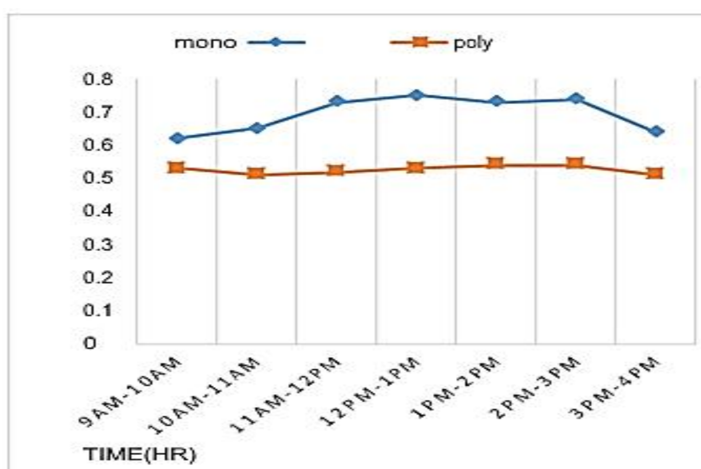
Dai -1: 45 degrees tilt



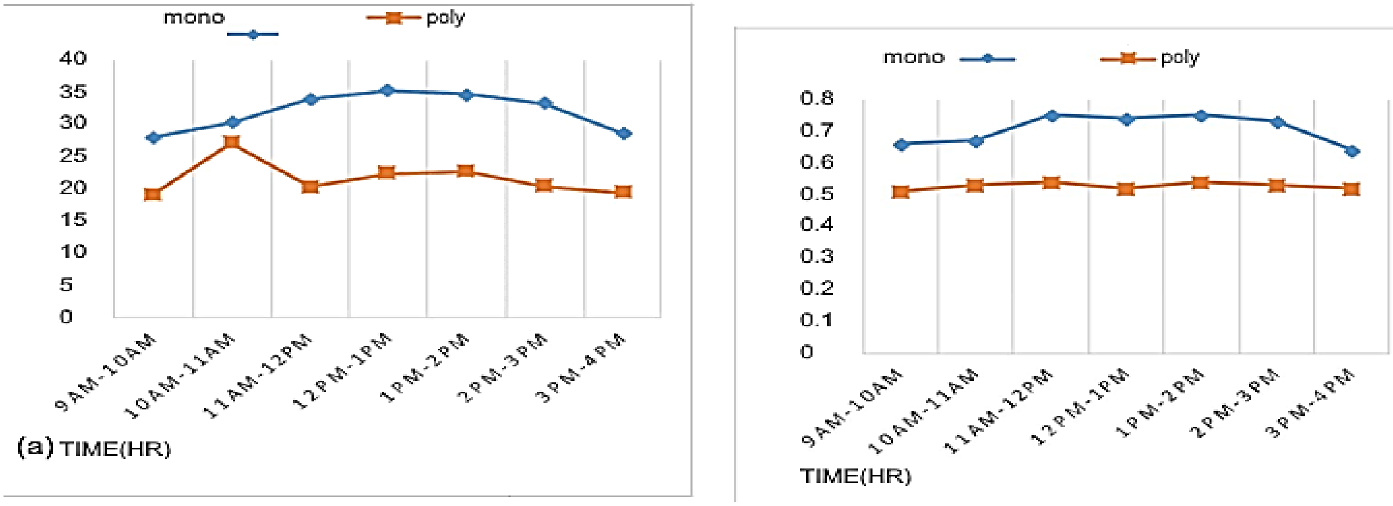


Day – 2: 45 degrees tilt





Day – 3: 45 degrees tilt



Day – 4: 45 degrees tilt

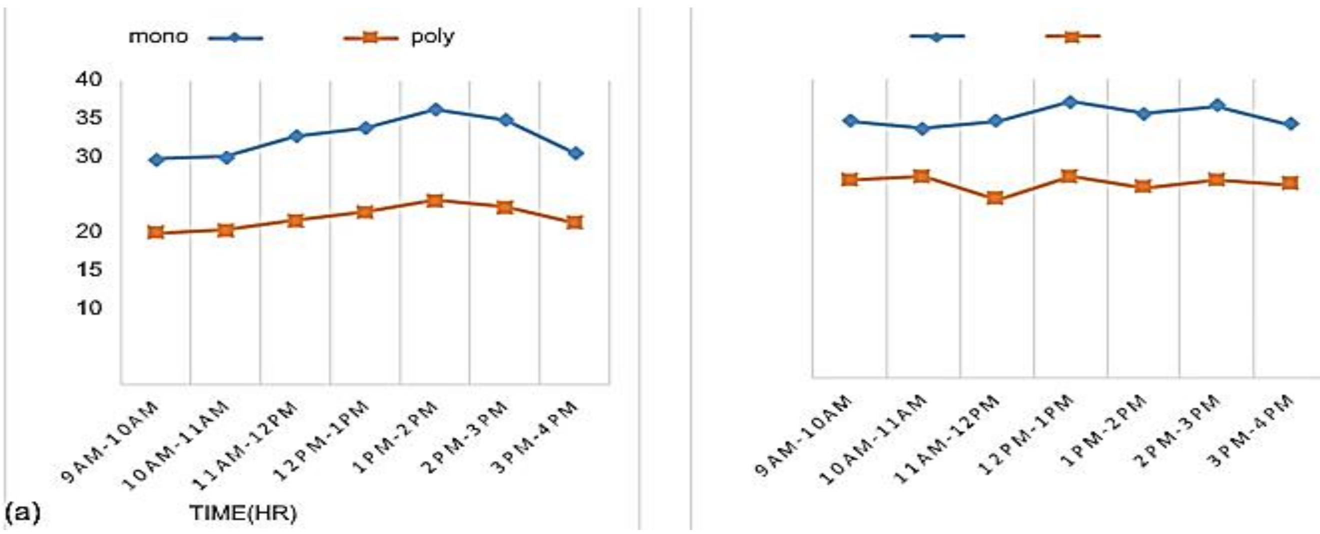


Table – 1: Total Average value for Monocrystalline panel

Tilt angle	Temperature	Vmpp	Impp	Pmpp	Efficiency
45^0	32.57^0C	30.82	0.7	22.04	10.54
15^0	32.25^0C	36.20	0.77	27.78	13.8
0^0	29.56^0C	32.20	0.75	28.11	11.86

Table – 2: Total Average value for Polycrystalline panel

Tilt angle	Temperature	Vmpp	Impp	Pmpp	Efficiency
45^0	32.21^0C	18.37	0.53	10.12	5.07
15^0	29.54^0C	18.75	0.66	12.29	6.13
0^0	32.57^0C	20.895	0.53	11.09	5.55

Calculation

$P_{mpp} = I_{mpp} \times V_{mpp}$

$\text{Efficiency} = \frac{P_{out}}{P_{in}} \times 100$

Where P_{in} = input power

$P_{mpp} = P_{out}$

5. Conclusion

The main objective of analyzing and determining the efficiency of polycrystalline solar panel and then comparing the values obtained for monocrystalline solar panel with the ones obtained for polycrystalline solar module was successful. From the result obtained, the efficiency of the monocrystalline panel was higher than that of polycrystalline solar panel. The result shows that the 15° tilt angle gave the highest efficiency compared to the other tilt angles.

6. Recommendation

The following observations are based on the test and experience carried out during the implementation of the work. For better output performance, the solar module should be placed on a stand that can be easily adjusted, for easy change of orientation and tilt angle. An automatic solar tracker should be used so as to track the sun which moves during the course of the day, so as to get the highest efficiency and to prevent manual adjustment. The panel should be placed in such a way that nothing will cast shadow on it or prevent its cells from receiving maximum intensity of light from the sun.

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