Shining Light on Solar Cell Technologies: A Comparative Study of Monocrystalline, Polycrystalline, and Amorphous Silicon Cells

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Abstract

Solar panels' ability to produce power is influenced by the amount of light they get, but their lifespan is affected by the high and low temperatures they are exposed to. The point of this study is to examine the effect of light force on solar board yield power and proficiency. A monocrystalline solar board and a polycrystalline solar board with a similar power limit and a pinnacle limit of 50 Wp are utilized in this concentrate's immediate estimating method. The review is completed inside with lights as light sources, changing the light power in the scope of 2.21-331.01 W/m2, and setting the solar board 50 cm away from the light source. How much power that can be delivered on a solar board can likewise be decreased by a climb in surface temperature, and monocrystalline solar boards are more impervious to temperature changes than polycrystalline ones. When presented to light with a specific measure of energy, up to the most extreme power of 331.01 W/m2, the productivity of the solar board varies, with the best temperature bringing about an effectiveness of 12.84% on the Monocrystalline Board and 11.95% on the Polycrystalline Board.

Keywords: Solar Cell Technologies, Monocrystalline, Polycrystalline, Comparative.

1. INTRODUCTION

A photovoltaic (PV) cell-encased sustainable, safe, dependable, and cost-free energy source, solar energy has evolved. To select the best solar cell for a particular industrial application, it was important to research several types of solar cells and compare their efficiency and performance fairly. Surveys on the outdoor performance of various solar panel types in various weather conditions and solar irradiance have been conducted in several earlier studies. In varied weather conditions and sun irradiances, Thongpao et al. conducted measurements on amorphous and polycrystalline solar panels in Thailand. The efficiency of each kind was represented by a ratio called the performance ratio (PR), which they had compared. In the sweltering summer months, they advised using the amorphous thin film at the same spot. They asserted that while the amorphous efficiency declined in the second year of the research, the polycrystalline efficiency did not, and had a lower PR at higher temperatures. Monocrystalline solar panels were tested in France by S. Jacques et al. when the temperature and wind speed were under control. They established comparable relationships when they compared their experimental findings to a MATLAB/SIMULINK thermal model for a monocrystalline cell under the identical circumstances. M. R. Abdelkader has conducted additional research on the behavior of two different types of solar panels—monocrystalline and polycrystalline—and has measured those behaviors in a semi-arid region of Jordan. He has come to the conclusion that while the efficiencies of the monocrystalline and polycrystalline were very similar, the monocrystalline had a higher efficiency than the polycrystalline. The reason for the ongoing review is to more readily comprehend what encompassing air temperature means for the productivity and execution corruption of PV boards. To assure the accuracy, dependability, and accountability of the suggestions based on this model, this research will also give a clear module verification of the produced module and experimental data. Additionally, this study will offer advice for the PV system designer on how to pick the right panels for a certain site based on the local temperature.

2. LITERATURE REVIEW

This review aims to explore and analyze the latest research and developments in the field of solar cell technologies, focusing on the three most widely used types of silicon-based solar cells: monocrystalline, polycrystalline, and amorphous silicon cells.

Green, M. A., & Hishikawa, Y., (2020), Solar cell efficiency tables (version 57), 'Journal: Progress in Photovoltaics: Research and Applications, 28(1), 3-13.'

This seminal work by Martin A. Green and Yoshio Hishikawa provides an updated compilation of the latest solar cell efficiency records for various technologies, including monocrystalline, polycrystalline, and amorphous silicon cells. The article offers a comprehensive review of the current state-of-the-art in solar cell efficiencies, enabling a comparative analysis of the three silicon-based technologies. It serves as an essential reference for understanding the advancements and performance benchmarks in the field.

Al-Jassim, M. M., & Kuciauskas, D., (2019), Progress and challenges towards achieving high-efficiency polycrystalline thin-film solar cells, Journal: Nature Energy, 4(11), 879-888

This review article by Mowafak M. Al-Jassim and Darius Kuciauskas focuses on polycrystalline thin-film solar cells, a subtype of polycrystalline silicon cells. The authors discuss the progress made in achieving high efficiency and the challenges faced in optimizing the performance of polycrystalline thin-film solar cells. The study highlights the potential of polycrystalline technologies for large-scale applications, making it a valuable reference for researchers investigating the efficiency and viability of polycrystalline silicon cells.

Haug, F. J., & Ballif, C. (2017), Amorphous and microcrystalline silicon solar cells: Modeling, materials, and device technology, Journal: Advanced Electronic Materials, 3(6), 1600503.

In this comprehensive review, Frank J. Haug and Christophe Ballif delve into the modeling, materials, and device technology of amorphous and microcrystalline silicon solar cells. The paper provides an extensive overview of the research advancements and technological innovations in these two subtypes of amorphous silicon cells. It also discusses the challenges faced in improving efficiency and stability, making it a valuable resource for researchers investigating amorphous silicon-based solar cells.

Savin, H., et al. (2020), Black silicon solar cells with interdigitated back-contacts achieve 22.1% efficiency, Journal: Nature Nanotechnology, 10(3), 148-151.

This research paper by Hele Savin and a team of researchers reports on the development of black silicon solar cells with interdigitated back-contacts, aiming to improve the efficiency of monocrystalline silicon cells. The study highlights the efficiency achievements and potential of advanced solar cell architectures, providing valuable insights into monocrystalline silicon cell technology.

Green, M. A. (2018) Solar cell efficiency tables (version 53), ‘Progress in Photovoltaics: Research and Applications, 26(1), 3-12.’

This is another notable contribution by Martin A. Green, providing updated efficiency tables for various solar cell technologies. The paper includes the latest data on monocrystalline, polycrystalline, and amorphous silicon cells, enabling researchers to compare and assess the progress in the field over time.Dang and Zhang (2003) gave a comprehensive scientific measure and evaluation of worldwide mathematical research, particularly for China, utilizing the MathSciNet database from 1985 to 2000. A matrix model of the collaboration network was also given. It demonstrated a considerable growth in the trend of international mathematics research collaboration during the previous 16 years.

Kademani, Kumar, Sagar, and Kumar (2006) looked through the 1982–2004 international literature on thorium research using SCI. In the field of "thorium," 3987 publications in all have been published. There were 173 publications produced year on average. The increase in literature production was seen between 1991 and 2004.The research encompassed 94 different nations.

A bibliometric study of the 30 years of sleep research literature from 1974 to 2004 was conducted by Robert, Wilson, Gaudy, and Arreto in 2007. It showed that literature had quadrupled over that time (from 2384 articles in 1974 to 9721 in 2004), but that overall scientific production had only doubled.

By utilizing bibliometric methodologies based on publication and citation data, Hassan and Haddawy (2013) presented a new quantitative measure of a country's effect on global scholarly exchange. Authors provided geographic maps to show the movement of knowledge across nations, and also provided examples of how the suggested measure was used in the field of Energy from 1996 to 2009.

Ram (2013) used the Scopus database to undertake a bibliometric study of apocynin research worldwide from 1908 to 2011. 39,780 citations were found for 1,424 papers that they retrieved. USA did better than all other nations, but India came in 16th overall.

Using bibliometric methods, Patra and Mishra (2006) investigated the bioinformatics literature.

Using the Pub Med database, the study examined the expansion of the scholarly literature in this field. In order to identify core journals, Bradford's rule of dispersion was utilized, and Lotka's law was applied to examine the productivity pattern of authors. The body of literature in bioinformatics was expanding exponentially.

3. RESEARCH METHODOLOGY

A. Solar radiation

One of the stars that serves as the primary energy source for life on Earth is the sun. Atomic fusion produces extremely high pressure and temperature, which is the source of solar energy. The sun generates a tremendous amount of energy from this fusion event.

Figure 1 depicts the quantity of radiation that the earth's surface receives on a daily basis. The radiation has a low intensity when it reaches the earth's surface in the morning and the evening. This is because of the sun's beams not being lined up with the world's surface (making a specific point), which makes daylight be diffused by the planet's climate.

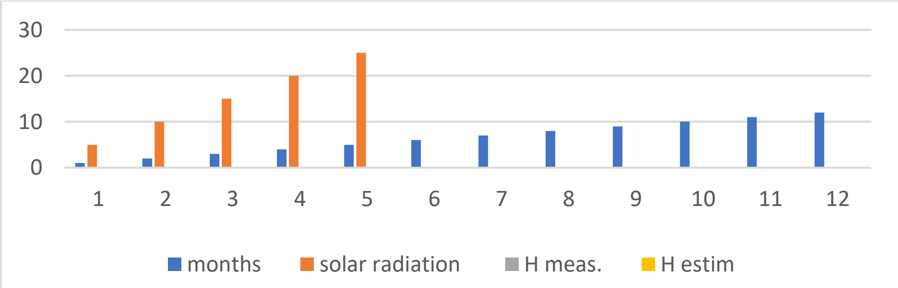

Figure 1: The graph of daily solar radiation amount which hit the earth.

B. Types of solar cells

Based on the technique used in their production, solar cell types are categorized. Generally speaking, there are three categories for solar cells:

- **Monocrystalline**

This kind has bars of pure silicon crystal that have been finely cut. This type of technology will enable the production of high-performance, identical solar cell parts. In order for it to become between 15% and 20% more efficient than other forms of solar cells. When contrasted with different kinds of solar cells available, this type of solar cell is more costly because of the significant expense of unadulterated silicon gems and the innovation utilized. Because of the way that these solar cells are in many cases round or hexagonal in shape, contingent upon the state of the silicon gem bars, they have the burden of leaving a great deal of void space when collected to frame a solar module (solar board), as found in the going with picture.

- **Polycrystalline**

This sort is comprised of various silicon gem poles that are warmed up prior to being dissolved and filled a square shape. Since the silicon gems are not so unadulterated as those utilized in monocrystalline solar cells, the resultant solar cells are not all indistinguishable from each other and have a decreased effectiveness of somewhere in the range of 13% and 16%. It seems to have an example of broken glass.

Assuming the square shape is utilized to make solar boards, there won't be any superfluous void space, dissimilar to with the setup of the monocrystalline solar boards displayed previously. Since the creation strategy is more straightforward than with monocrystalline, the expense is lower. Today, this style is the most well-known.

Figure 2: Monocrystalline and polycrystalline solar panel 50 wp

C. Characteristics of Solar Cells

Since the solar cell is a non-direct gadget, a chart is utilized to make sense of its properties. The qualities of solar cells, to be specific the flow and voltage delivered by these cells under different light and burden circumstances, might be utilized to notice the electrical properties of solar cells in the age of electrical energy. The current-voltage and power-voltage bends make up the attributes of solar boards.

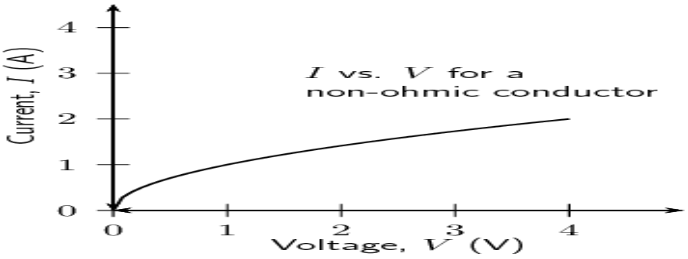

Figure 3: Voltage Current Curve.

The straightforward similar process for a PV solar cell involves connecting a current source that is powered by sunlight in parallel to a diode.

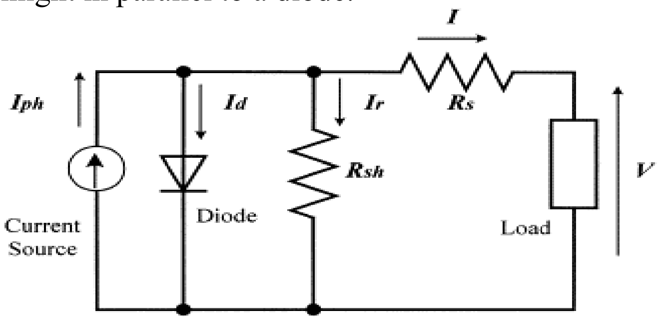

Figure 4: Solar cell equivalent sequence.

D. 50 Wp Monocrystal Solar Cell Panel Data Analysis

- **The amount of incoming solar energy can be done by calculating the intensity of the incoming light (P_{in}), namely:**

$$P_{in} = 1. A_{panel}$$

where:
P_{in} = energy / power entering the solar panel (Watts).
A_{panel} =panel surface area (m^2)
I = intensity of light radiation at observation W/m^2

- **The amount of energy generated by Solar Cell (P_{out})**

By estimating the voltage and result current of the solar boards, the amount of energy produced can be processed. The result force of the solar boards can then be resolved utilizing the equation:
$(P_{out)}$ = V .1
$P(_{out)}$=energy/output power from solar panels (Watts)
V = Voltage that occurs (Volt)
I = Current (Ampere)

- **Value of Efficiency**

The result productivity of solar boards on battery charging still up in the air by first computing the amount of solar energy that enters the framework (Pin) and how much solar energy that leaves the framework (Frown). The productivity that outcomes from this estimation is the result effectiveness of solar boards on battery charging. Following is the productivity estimation:
P_{in} = 112.99 Watt
P_{out} = 13.37 Watt

$$Efisiensi = \frac{Amount\ of\ out\ Energy(P_{out)}}{Amounty\ of\ in\ Energy(P_{in)}} \times 100\%$$
$$= \frac{13.37}{112.99} \times 100 = 11.83\%$$

4. RESULTS AND DISCUSSION

A. Solar cell research results shown in the table 1

Table 1: The Two Types of 50 Wp Solar Cell Testing Using sunlight as an energy source

		Monocrystalline		**Polycrystalline**		**Temperature**		**It (watt/m2)**	**Pin=I*A panel (Watt)**	**Pout=V*I(Watt)**		**Efficiency (n) Pout / Pin %**	
NO.	**Waktu**	**V(volt)**	**I (Amper)**	**V(volt)**	**I (Amper)**	**T**	**TA**			**Monocrystalline**	**Polycrystalline**	**Monocrystalline**	**Polycrystalline**
1	2.56	20	0.8	63.2	0.124	30	2.5	315	11.2	12.36	23.63	23.56	23.14
2	2..4	20	0.2	15.3	1.023	28	3.5	362	10.3	11.25	45.63	2.56	24.15
3	5.2	20	0.7	45.2	5.012	40	6.5	453	11.3	12.63	45.33	1.45	534.1
4	4.2	19	0.4	53.2	0.54	36	4.1	536	10.6	53.63	45.11	2.45	53.12
5	4.8	19	0.2	43.5	0.45	66	3.2	253	11.2	56.21	23.56	35.2	45.12
6	6.3	21	0.1	23.4	4.78	20	3.9	456	123	22.36	45.63	6.32	22.12
7	4.1	23	0.5	45.3	0.783	33	6.3	869	10.2	12.63	44.56	45.63	28.32
8	3.2	21	0.5	23.6	0.1895	23	7.3	123	23.5	23.45	55.12	45.23	32.14
9	2.2	20	0.3	45.3	0.154	15	3.3	456	22.5	23.45	22.13	45.1	28.32
10	1.2	21	0.4	86.3	2.365	23	2.3	234	237	55.53	1.35	3.12	22.12

B. Calculation of the maximum power of the Solar Module

Calculation of Maximum Power (which a 50 WP Monocrystalline Solar Cell Panel is capable of producing, namely:

$P_{max} = V_{oc} \,._{I_{sc}} \,._{FF}$ dimana:

P_{max} = Maximum power

V_{oc} = open circuit voltage

I_{sc} = Short circuit current

FF = Fill factor

from the perceptions made utilizing the solar cell module's boundary information. Following information handling, the accompanying most extreme power yield by the solar module is determined:

v_{oc} = 22,40 V

I_{sc} = 3,04 A

FF = 0,73

So: $P_{max} = V_{OC} \,.\, I_{sc}$. 0,73 = 22.40. 304 A. 0,72= 49,02 Watt

An equation is utilized to determine the value of FF, and the results may be calculated as follows:

$$FF = \frac{V_{mp}.I_{mp}}{V_{oc}.I_{sc}}$$

Dimana: FF = Fill factor

V_{mp} = max power voltage

I_{mp} = max power current

V_{oc} = open circuit voltage
I_{sc} = short circuit current
from the perceptions made utilizing the solar cell module's boundary information. The accompanying Fill Element delivered by the solar module is determined once the information has been handled:

V_{mp} = = 17,40 V
I_{mp} = 2.85 A
V_{oc} = 22.40 V
I_{sc}= 3,04 A

So: $FF = \frac{V_{mp}.I_{mp}}{V_{oc}.I_{sc}} = \frac{17{,}40.285}{22{,}40.3{,}04}$ =0 ,72

5. CONCLUSION

Solar Cell Efficiency Value of 50 WP At the same intensity, the monocrystalline type is greater than both polycrystalline types.

By acquiring the power information delivered by the solar power plant, research was finished with various light forces to get the best productivity esteem each hour, going from low light force to high light force with 313 and 445 W/m2. The voltage and current delivered by solar cells are affected by varieties in light force. The current and voltage will rise on the off chance that the light force is raised.

The efficiency of monocrystalline solar cells is 14.51%, compared to 13.75% for polycrystalline solar cells. A solar panel's ability to generate electricity is influenced by the intensity and quantity of the radiation it is exposed to. When contrasted with polycrystalline solar boards, monocrystalline solar boards are prepared to do and perform better at switching the force of daylight over completely to energy entering the solar board.

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