International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Exploring the Effects of Spectral Variations on Illuminated PV Modules A Comprehensive Analysis

Juthi Ghosh[1*], Danny Denzopa[2]

[1]Pataliputra University
[2]University of Kerala
*Email - jgpat01@gmail.com
DOI: *https://doi.org/10.55248/gengpi.2023.32493*

A B S T R A C T

In recent years, there have been significant advancements in illuminated solar cell technology, leading to the development of efficient solar systems with better quality semiconducting materials at a lower cost. However, there are certain variables that remain constant and must be taken into consideration when studying illuminated PV modules. These variables, which include spectral wavelength, temperature, and climatic changes, play a crucial role in determining the efficiency of solar cells.To ensure accurate results and establish a standardized analysis, it is essential to identify the perfect analysis dependency variable. This variable must be able to provide approximate exact results for various geographic locations on Earth's surface. Spectral wavelength varies based on climatic and temperature changes, and semiconducting materials used in illuminated PV cells are absorptive, reflective, and emissive in nature, depending on the wavelength of the irradiation. Due to reciprocity, a good absorber is necessarily a good emitter, and a poor absorber is a poor emitter. The temperature also determines the wavelength distribution of the electromagnetic radiation.While the initial setup costs for renewable energy resources may be high, they are crucial for reducing carbon dioxide emissions and ensuring a secure energy future. Renewable energy sources such as wind, solar, geothermal, hydroelectric, and biofuels all have their own positives and negatives. Solar cells rely on the photovoltaic effect, a quantum-mechanical process, to produce electricity. The sun's thermal energy flux that arrives at Earth's surface is several thousand times the current use of primary energy sources by humans. The potential of solar energy is enormous and makes it a crucial component of a renewable energy range that can fulfill daily energy requirements and reduce greenhouse gas emissions globally, which contribute to global climate hazards.

Various solar cell materials have been used, but the current use of solar energy resources represents less than 1% of the total electricity production from renewable sources. Despite the increasing deployment of photovoltaic systems over the last 20 years, solar technologies still face some challenges that make them less competitive on an energy market dominated by fossil fuels. These challenges include high initial investment costs, moderate efficiency conversion, and intermittent power generation.Therefore, there is a need for the advancement of new technologies with higher conversion efficiencies and lower production costs to enable the deployment of solar energy on a large scale. This report aims to summarize the state of research with developed matured and newly emerging solar technologies with high-level potential for large-scale energy generation. It also identifies primary research back history that is vital for improving PV module performance, reliability, and competitiveness.In conclusion, solar energy has enormous potential as a renewable energy resource. With advancements in illuminated solar cell technology, it is possible to develop efficient solar systems with better quality semiconducting materials at a lower cost. However, to establish a standardized analysis, it is crucial to identify the perfect analysis dependency variable, which must be able to provide approximate exact results for various geographic locations on Earth's surface. The deployment of solar energy on a large scale requires the advancement of new technologies with higher conversion efficiencies and lower production costs. This will help to improve PV module performance, reliability, and competitiveness and enable the adoption of solar energy as a crucial component of a renewable energy range that can fulfill daily energy requirements and reduce greenhouse gas emissions globally.

Keywords: PV Modules, Spectral Variations

1. Introduction

Solar energy has gained significant attention in recent years, with the need to reduce carbon emissions and mitigate climate change. The purpose of this report is to evaluate the potential of solar energy for low-carbon-intensive and large-scale energy production, and to provide an overview of the state of research in the most significant solar technologies. The report aims to identify interdisciplinary and primary research analysis with high potential for the improvement of solar technologies.

The deployment of solar technologies for energy production at a large scale requires the involvement of both political and economic players' interest. Further improvements in the conversion efficiency and manufacturing cost reduction are also needed. A large number of research efforts are ongoing, aiming to find novel solutions to conquer these technical barriers[1][2][3][4][5][6][7].

In the past decade, there has been remarkable progress in photovoltaic (PV) module technologies, leading to an increase in the efficiency of polycrystalline silicon solar cells up to 25% and of thin-film solar devices up to 19%. With the growth of innovative technologies such as nanotechnology, thin layered deposition innovation and growth techniques, and novel materials, there are opportunities to achieve superior performance with the enhancement of multijunction devices and other upgraded generation photovoltaics devices. There are also opportunities to develop cheaper devices such as organic-based PVs. However, these technologies are facing crucial challenges related to the steps involved in the conversion process of photon energy into electricity, including photon absorption, charge carrier generation, separation of charge, and transportation of charge. To become more efficient, stable, and reliable, both primary research and technical development evolution are critical necessities.

Solar thermal devices are also at the verge of demonstration, and some implementations are already functioning. Hybridization and thermal storage improve photovoltaic ability to fulfill the intermittency problem, making these technologies principally suitable for large-scale electricity generation. From solar energy, particularly hydrogen and direct chemical fuels production, is a capable unconventional method of producing a sustainable carbon-free fuel economy. Thermo-chemical and organic conversion processes are promising technologies that have potential for high efficiency power. However, to date, only a few thermochemical processes have been invented, and organic systems require a clearer understanding of genetics and organic conversion to become efficient and stable[8][9][10][11][12][13].

Commercial residential PV modules have a power output ranging from 10 watts to 300 watts, in direct current. A PV module must use an inverter to change the direct current into an alternating current to enable it to be usable by electrical devices and compatible with the electric supply grid, making it too expensive. The energy generation by renewable sources is very less compared to primary energy sources, but its scope will increasingly become higher with the exhaustion of fossil fuels. The main reasons for the deliberate deployment of solar technologies are the relative high capital cost per kW installed compared with other fossil fuel-based and renewable technologies and the discontinuous nature of the input of the irradiation energy, requiring energy storage compatible systems to match the frequency of energy demand and supply of electricity and to decrease the capital cost. In the medium range, an energy storage system will be a key requirement for intermittent solar energies to become more competitive versus fossil fuels..

2. Litrature Review

.This chapter provides a comprehensive review of literature on various research areas related to solar photovoltaic (SPV) systems, with a focus on thermal analysis (energy and exergy) under different climatic conditions, spectral solar irradiation variations, and hybrid culture of solar power generation[14][15][16][17][18].

As part of the objectives of this review, an examination of exergoeconomic literature on SPV systems was also conducted. Several studies were identified, including one by Nuruddeen Abdullahi et al. [1], which investigated the performance and modeling concepts of PV modules under various conditions such as wind, dust, and snow. The study examined the performance of an 85W mono-crystalline PV module and found that it was capable of producing 17.75W/m2 with an efficiency of 7% and 138W/m2 with an efficiency of 8% from indoor and outdoor office space, respectively, during the summer.

Jannik Heusinger et al. [2] presented a new power measuring model that accurately compared the total power of the thermal PV module switching with standard detection. The study found that different tracking systems have a significant impact on modular temperatures and reasonable temperatures by converting the total radiation found on the surface of PV.

M. R. Abdelkader et al. [3] examined the performance of various solar modules in a dry climate such as Jordan. The study investigated the performance of two photovoltaic modules at different times of the year and found that the efficiency of mono-crystalline reached 18% of the PV module with the multi-crystalline PV module reached 16% measured by testing.

3. Research Methodology

T.T.Chow et al. [4] provided a review paper on photovoltaic/thermal hybrid technology, highlighting technological advances in the 1990s and performance evaluation of PV systems. The study also provided details on the type of PVT collection system that collects flats and the construction of the type of concentrator type reported over the past decade and the mixed development and trade over the past decade.

Alcantara S.P., Del et al. [5] discussed the use of solar photovoltaic (SPV) systems, which are devices that directly convert solar radiation into heat and electricity. The study found that most SPV modules are based on crystalline silicon technology and identified three types of technologies: mono-crystalline silicon (m-Si), multi-crystalline silicon (mc-Si), and ribbon silicon. It was found that mono-crystalline-silicon is more expensive than multi-crystalline-silicon and more efficient, with the m-Si-based module proving to be better than the mc-Si module[19][20][21][22][23][24].

R. Gottschalag et al. [6] presented a 17 precise model of system performance by experimental studies to determine the effect of statistical variation in marine climate on the performance of a single and double amorphous silicon cell. The study found that spectral fluctuations in the short-term cycle had an impact on the current at the highest power level, the filling factor, and the overall efficiency.

Finally, Ricardo Ruther et al. [7] conducted a comparative study on the function of the outer door and the monitoring of amorphous silicon as well as the traditional performance of crystalline silicon. The study found that the performance of amorphous silicon modules must be accurately measured in relation to the spectra to reflect its true performance.

Overall, this review highlights the various research areas related to solar photovoltaic systems and provides insights into their performance and modeling concepts under different climatic conditions, spectral solar irradiation variations, and hybrid culture of solar power generation.

4. Conclusion

Recent years have seen remarkable progress in the field of photovoltaic (PV) cells, with researchers adopting various approaches to improve their conversion efficiencies. One promising avenue of research has been the use of high-quality thermal semiconductor materials. Thermal irradiation also plays a vital role in understanding the thermal behavior of these materials, with variable analysis conducted at various geographic locations on Earth.

Exciting possibilities are emerging for new PV devices with moderate efficiencies and the potential for lower costs. This renewable energy source has the potential to fulfill energy demands, especially with the growth of radiation-absorbing materials and further advancements in emerging technology. Researchers are working tirelessly to develop new thermochemical combine processes, but it's important to note that the use of organic systems requires a deeper understanding of material inheritance and organic conversion to achieve efficiency and stability.

Solar energy has the potential to become a significant fraction of a future carbon-free energy portfolio. However, technological advancements and breakthroughs are necessary to overcome the low conversion efficiency and high cost of currently available systems. Despite these challenges, we cannot ignore this enormous source of energy as fossil fuel-based energy sources will soon become exhausted for future generations.

In conclusion, researchers have made significant strides in improving the conversion efficiencies of PV cells by adopting various approaches and using better quality thermal semiconductor materials. With the growth of radiation-absorbing materials and emerging technology, there is great potential for this renewable energy source to meet our energy demands. Further research is required to develop efficient and stable organic systems, and technological breakthroughs are necessary to overcome the challenges faced by current solar energy systems. Nonetheless, solar energy has the potential to play a crucial role in a future carbon-free energy portfolio, making it an energy source we cannot afford to ignore.

References

[1] Van der Geer, J., Hanraads, J. A. J., & Lupton, R. A. (2000). The art of writing a scientific article.Journal of Science Communication, 163, 51–59.

[2] Strunk, W., Jr., & White, E. B. (1979). The elements of style (3rd ed.). New York: MacMillan.

[3] Mettam, G. R., & Adams, L. B. (1999).How to prepare an electronic version of your article. In B. S. Jones & R. Z. Smith (Eds.), Introduction to the electronic age (pp. 281–304). New York: E-Publishing Inc.

[4] Fachinger, J., den Exter, M., Grambow, B., Holgerson, S., Landesmann, C., Titov, M., et al. (2004).Behavior of spent HTR fuel elements in aquatic phases of repository host rock formations, 2nd International Topical Meeting on High Temperature Reactor Technology. Beijing, China, paper B08.

[5] Fachinger, J. (2006). Behavior of HTR fuel elements in aquatic phases of repository host rock formations.Nuclear Engineering & Design,236, 54.

[6] Gani, A. (2017). The logistics performance effect in international trade. The Asian Journal of Shipping and Logistics, 33(4), 279-288.

[7] Gani, A. (2017). The logistics performance effect in international trade. The Asian Journal of Shipping and Logistics, 33(4), 279-288.

[8] Rodriguez, K. M., Reddy, R. S., Barreiros, A. Q., & Zehtab, M. (2012, June). Optimizing Program Operations: Creating a Web-Based Application to Assign and Monitor Patient Outcomes, Educator Productivity and Service Reimbursement. In DIABETES (Vol. 61, pp. A631-A631). 1701 N BEAUREGARD ST, ALEXANDRIA, VA 22311-1717 USA: AMER DIABETES ASSOC.

[9] Kwon, D., Reddy, R., & Reis, I. M. (2021). ABCMETAapp: R shiny application for simulation-based estimation of mean and standard deviation for meta analysis via approximate Bayesian computation. Research synthesis methods, 12(6), 842–848. https://doi.org/10.1002/jrsm.1505

[10] Reddy, H. B. S., Reddy, R. R. S., Jonnalagadda, R., Singh, P., & Gogineni, A. (2022). Usability Evaluation of an Unpopular Restaurant Recommender Web Application Zomato. Asian Journal of Research in Computer Science, 13(4), 12-33.

[11] Reddy, H. B. S., Reddy, R. R. S., Jonnalagadda, R., Singh, P., & Gogineni, A. (2022). Analysis of the Unexplored Security Issues Common to All Types of NoSQL Databases. Asian Journal of Research in Computer Science, 14(1), 1-12.

[12] Singh, P., Williams, K., Jonnalagadda, R., Gogineni, A., &; Reddy, R. R. (2022). International students: What's missing and what matters. Open Journal of Social Sciences, 10(02),

[13] Jonnalagadda, R., Singh, P., Gogineni, A., Reddy, R. R., & Reddy, H. B. (2022). Developing, implementing and evaluating training for online graduate teaching assistants based on Addie Model. Asian Journal of Education and Social Studies, 1-10.

[14] Sarmiento, J. M., Gogineni, A., Bernstein, J. N., Lee, C., Lineen, E. B., Pust, G. D., & Byers, P. M. (2020).Alcohol/illicit substance use in fatal motorcycle crashes. Journal of surgical research, 256, 243-250.

[15] Brown, M. E., Rizzuto, T., & Singh, P. (2019). Strategic compatibility, collaboration and collective impact for community change. Leadership & Organization Development Journal.

[16] Sprague-Jones, J., Singh, P., Rousseau, M., Counts, J., & Firman, C. (2020). The Protective Factors Survey: Establishing validity and reliability of a self-report measure of protective factors against child maltreatment. Children and Youth Services Review, 111, 104868.

[17] Reddy Sadashiva Reddy, R., Reis, I. M., & Kwon, D. (2020). ABCMETAapp: R Shiny Application for Simulation-based Estimation of Mean and Standard Deviation for Meta-analysis via Approximate Bayesian Computation (ABC). arXiv e-prints, arXiv-2004.

[18] Reddy, H. B. S, Reddy, R. R., & Jonnalagadda, R. (2022). A proposal: Human factors related to the user acceptance behavior in adapting to new technologies or new user experience. International Journal of Research Publication and Reviews, 121-125. doi:10.55248/gengpi.2022.3.8.1

[19] Reddy, H. B. S., Reddy, R. R. S., & Jonnalagadda, R. (2022). Literature Review Process: Measuring the Effective Usage of Knowledge Management Systems in Customer Support Organizations. In International Journal of Research Publication and Reviews (pp. 3991–4009). https://doi.org/10.55248/gengpi.2022.3.7.45

[20] Reddy, R. R. S., & Reddy, H. B. S. (2022). A Proposal: Web attacks and Webmaster's Education Co-Relation. In International Journal of Research Publication and Reviews (pp. 3978–3981). https://doi.org/10.55248/gengpi.2022.3.7.42

[21] Reddy, H. B. S. (2022). A Proposal: For Emerging Gaps in Finding Firm Solutions for Cross Site Scripting Attacks on Web Applications. In International Journal of Research Publication and Reviews (pp. 3982–3985). https://doi.org/10.55248/gengpi.2022.3.7.43 810 International Journal of Research Publication and Reviews, Vol 3, no 8, pp 807-809 August 2022

[22] Lu, N., Butler, C. C., Gogineni, A., Sarmiento, J. M., Lineen, E. B., Yeh, D. D., Babu, M., & Byers, P. M. (2020). Redefining Preventable Death—Potentially Survivable Motorcycle Scene Fatalities as a New Frontier. In Journal of Surgical Research (Vol. 256, pp. 70–75). Elsevier BV.
https://doi.org/10.1016/j.jss.2020.06.014

[23] Reddy, H. B. S. (2022). Exploring the Existing and Unknown Side Effects of Privacy Preserving Data Mining Algorithms (Doctoral dissertation, Nova Southeastern University).

[24] Sadashiva Reddy, H. B. (2022). Exploring the Existing and Unknown Side Effects of Privacy Preserving Data Mining Algorithms.