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A Review on Predictive Methodologies for Enhancement of Solar PV Cell Efficiency

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Abstract

Designing of efficient solar PV cells to meet the socio-economical power demand is the key challenge to the electrical design engineers. Solar energy is the one of the key renewable energy source compared to the other renewable energy sources. Most of the research works are transacted different methodologies based on algorithm based maximum power point tracking techniques. All the methodologies are concentrated on tracking of solar cells in the direction of sun light and confirmed that limited power generation only. Also, many authors stride in to different methodologies to obtain the enhancement of solar cell efficiencies. All these methodologies are limited to solar power generation due to irregular light energy irradiations in the universe and results in significant affect on power demand in day to day life. This authenticates that, need of alternative methodologies to meet the continuous solar power generation in order to meet the constant power demand. Also, it recommends that, need of vast research work to obtain enhanced solar PV cell efficiency. In view of this, authors are tried to review the research work done in elsewhere in the world and made new approaches to meet the increased power demand. This paper presents the review of different methodologies presented elsewhere in the world. Also, this paper discussed the new approach to obtain the socio-economic solar panel designs to meet the enhanced solar PV cell efficiency and space occupation problem of solar panels.

Keywords*— Solar tower, solar panel, reflector, light source.*

I. Introduction

The socio-economical power demand in day to day life due to increased population becomes one of the major issues to the electrical engineers. Renewable energy sources [1] like hydal, tidal, thermal and biomass etc. have limited due the lack of availability and design constraints. Solar power energy is the one of the renewable energy [2] sources playing a major role to meet the power demand in day to day life as compared to the other renewable energy sources. Countries are now concentrated to replace all their existing power pants with solar power plants step by step as ample of solar energy in the universe freely. Recently, new project was introduced named as floating photo voltaic (FPV) [3] [4] on rivers generate the electrical energy and is shown in figure 1. This project aims to generate the 1,00,000 MW capacity in India in order to meet the power demand to surrounding areas.Not only the floating photo voltaic design considerations, but it is also observed that, some research works introduced design of solar panels in solar tower type structure and is observed from [5]

Many authors are developed different methodologies to extract this abundant of solar energy for generation of electrical energy. All these methods are concentrated extraction of solar light at appropriate angle of incidence initially and modified to maximum power extraction by tracking the solar cells in the solar light directions. The maximum power point tracking [6] [7] of solar power becomes most popular in later and made directions to many authors for maximum power extraction from solar panel. It is observed that, the different algorithm based techniques for maximum power extraction [8] [9] from solar panel involves sensor based program

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controlled techniques given acceptable results but not satisfied operations.

Figure 1. Floating photovoltaic (FPV)

It is also observed that, some of the authors adopted concept of light reflection [10][11] method to extract the maximum power from the solar cells and attempted the design models. The designing of solar panels using light reflector methods are giving acceptable results which will meet the required power demand. It is observed that, the results published in the research works elsewhere in the world shows that enhanced solar cell efficiencies for different panel arrangements. This light reflector methods used continuous light reflector arrangement using white sheets, aluminum sheets, and mirrors are the reflectors [12]. It is reported that, these reflecting materials are giving same output of incident light power. But, the designing of these reflectors along with solar panel consumes more space constraints. This authenticates that, the proper designing of solar panels using light reflector arrangement methods consumes more space occupation [13]. This dictates that, there is a need in vast research work to overcome this space occupation problem.In view of this, authors are interested to review the research work carried in elsewhere in the world on the concept of enhancement of solar PV cell efficiency and attempted to suggest the modified solar panel design using light reflector to obtain enhanced cell efficiency along with less space occupation constraints. Therefore, this paper presents the different methodologies to obtain optimal solar panel designs in space as well as arrangement to obtain PV cell efficiency [14] constraints by reviewing research works published elsewhere in the world and made suggestions on superior methodology.

II. METHODOLOGY

The major methodology utilized to obtain the enhanced solar cell efficiencies is concept of light reflection method which was well established in ancient physics [11] [12]. It is well known fact that this concept of light reflection used in many applications such as surveillance, projectors, etcetera, movie screens etc. Not only in these minor applications but it also used in major applications such as study of earth Ionosphere [15] National Astronomy and Ionosphere Center and is shown in figure2 below. This confirms that, the concept of light reflection plays a vital role in the optimal solar panel design.

Figure 2. Arecibo observatory radio telescope

a. Concept of Reflection of Light

It is a well known concept explained in physics that the lightreflections depend on the nature of interface structures for different applications. The selection of interfacing surface is depends on the nature of application. Many applications used two types of interfacing structures are concave and convex shapes. The shape of the concave lenses is in parabolic curve shape [16] [19]. Regular reflection causes for plane surface interface units and diffused type of specular reflections are caused for irregular type interface units and is observed from the figure 3 below. For this solar panel type of interface units regular reflections are formed as they are in plane surface units. Suitable arrangements for light reflection may results in enhanced cell efficiencies.

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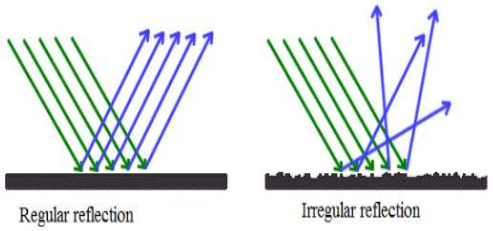

Figure 3. Types of Light reflections

Different interface surfaces having different reflection coefficients [17] which make a decision on selection of interface surfaces for different applications. Therefore, the reflection coefficientsof different materials are shown in figure 4 below. From the figure 4, it confirms that, the mirrors are the best light reflectors which give nearly same impact of incident light. The light reflection coefficients of silver sheets and quality mirrors are 1 and greater than 1respectively. Hence, it proves that suitable selection of reflecting interfaces may results in single input and multiple outputs with same and enhanced results. Therefore, authors are interested to design the solar panels with help of this light reflection concept. The following sections describe the possibilities of design of solar panels.

Total Reflection Coefficients of Various Surfaces

Material	Reflectance
Highly polished silver	0.92
Glass lined mirrors	0.70 to 0.85
White blotting paper	0.82
Emerald green paper	0.18
Black paper	0.05
Dark blue suit	0.03
Dark blue overcoat	0.02
Light grey suit	0.11
Grey suit	0.07
Caucasian (male) face, front	0.30 to 0.50
Negroid (male) face, front	0.10 to 0.30
Roadway (total of specular and diffuse)	
Macadam	0.06 to 0.13
Concrete	0.08 to 0.15
Dirt and gravel	0.03 to 0.07
Black velvet	0.004

Figure 4. Light reflection coefficients of different material

III. DESIGN MODELS OF SOLAR PANELS

a. Solar Panel Design with Reflector of white sheets

The solar panel design contains reflectors on inside of the solar panel walls and light energy source on the top of the solar panel is shown in figure 2. The reflectors in the walls of the solar panels are act as a light energy reflectors. The light energy reflectors in the solar panels are of silver or white color sheets which are stacked on the every corner of the inside wall of the solar panels. The reflection coefficient of light reflection for white sheets is greater than 1. The solar cells in the panels are arranged so that, the structure of the solar panel looks as a tower [12] structure and is shown in figure 5. The solar cells in the panel arranged as top and bottom with appropriate space between each solar cell. A light energy source is fixed at top of the solar panel and the solar cells are facing on the top of the light energy source. The light reflectors are arranged at wall inside of the solar panel and also back side of the each solar cell. As per design structure of solar panel it is difficult to project the light energy on bottom of the remaining solar cells. In order to overcome this problem, light reflectors are arranged on inside wall of the solar panel so that, achieve the equal light intensity in inside of the solar panel.

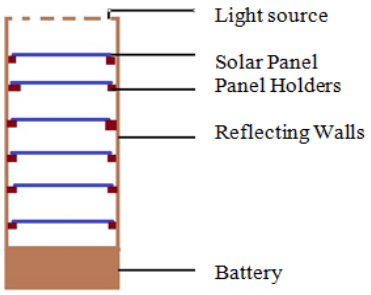

Figure 5. Solar tower 2-dimentional view

The design of solar panel in solar tower structure type confirms that, the panel design meets the space constraints. Not only have the space constraints, the tower type design with light reflectors also met the continuous extraction of maximum power.

b. Solar panels with reflectors of mirrors

In this type of designs, mirrors are used as reflectors in place of the white sheets which are used in above design. Mirrors are the one of the good reflectors which may give acceptable efficiency of in the solar panel designs. The design structure of this type of solar panels is also similar to the above designs. Mirrors are arranged on the wall of the inside of the solar panels, the weight of the solar tower increased

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as compared to above design and the structure of solar tower in three dimensional view is shown in figure 6 below

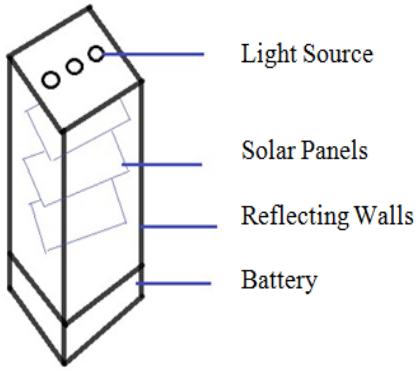

Figure 6. Solar tower 3-dimentional view

c. Solar panel design with instanteneous light energy

The efficiency of the solar cells increases by continuous instantaneous light energy reflections on the solar cells. As it is a well known concept that, an instantaneous light reflection on any object results in enhanced reflection intensity which have huge amount of energy compared continuous emerging light intensity. It is observed that the light reflection coefficients of instantaneous lights may varies more than one and 100 % for proper arrangement to different interface units. The instantaneous light reflection varies with different frequency bands and which is observedfrom the figure 7 below.

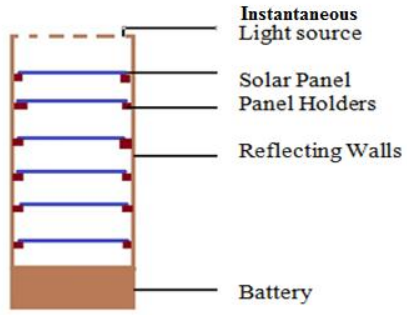

Figure 7. Instantaneous light source type solar tower 2-dimentional view

The instantaneous lights have enough kinetic energy as compared to continuous incident light energy. As compared to above two panel design considerations, this instantaneous light reflection panel designs improved solar panel out puts. This type of design may have an additional arrangement to obtain the movement of tilt of light reflectors with small angle. The frequency of instantaneous light reflections may arrange so that, the possibility of 143 % of reflection coefficient [18] can be achieved.As compared to above two methods of designs this type solar panel designs results in increased solar cell efficiency.

IV. ADVANTAGES OF SOLAR TOWER

As compared to existing solar panels, proposed solar panel design structure may have the following advantages:

- This type of design occupies less space
- It may achieve same and increased output as compared existing solar panels.
- Continuous power generation is possible with this type of designs for day as well as night time also.
- Less manufacturing cost as compared to the existing solar panel.
- Light source to this type of design can consumes less power as it have possibility of additional set up is allowed to recycle the power to light energy.

V. CONCLUSION

A detail review has been conducted and discussed on possibilities of enhancement of solar PV cell efficiencies presented elsewhere in the world. It is observed that, a serious drawback of existing solar panels is its availability of light energy for power generation using solar cells. This validates that the existing solar panels are limited to generate the electricity over a particular time period only. Hence, there is a need of new design techniques in solar panel design in order to overcome the continuous solar power generation problem. Therefore, arrangement of solar PV cells in tower structure may overcome the irregular light energy problems for solar power generation and also this

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type of design structure may results in same and enhanced output power with less space occupation. Specifically, solar cells in tower structure type panel with instantaneous light reflection arrangement results in enhanced solar panel efficiency.

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REFERENCES

[1] OjonugwaUsman, Andrew AdewaleAlola, Samuel AsumaduSarkodie, “Assessment of the role of renewable energy consumption and trade policy on environmental degradation using innovation accounting: Evidence from the US” , Renewable Energy (Elsevier), Volume. 150, PP.266-277, January 2020.

[2] OjonugwaUsman, Andrew AdewaleAlola, Samuel AsumaduSarkodie, “Promotion of solar energies usage in Iran: A scenario-based road map” , Renewable Energy (Elsevier), Volume. 150, PP.278-292, January 2020.

[3] D. Mittal, B. K. Saxena and K. V. S. Rao, "Floating solar photovoltaic systems: An overview and their feasibility at Kota in Rajasthan," *2017* International Conference on Circuit ,Power and Computing Technologies (ICCPCT), Kollam, 2017, pp. 1-7.

[4] C. H. B. Apribowo and A. Habibie, "Experimental Method for Improving Efficiency on Photovoltaic Cell Using Passive Cooling and Floating Method," 2019 6th International Conference on Electric Vehicular Technology (ICEVT), Bali, Indonesia, 2019, pp. 272-275.

[5] Q. Xie, Y. Xiao, X. Wang, D. Liu and Z. Shen, "Heliostat Cluster Control for the Solar Tower Power Plant Based on Leader-Follower Strategy," in IEEE Access, vol. 7, pp. 135031-135039, 2019.

[6] A. Sangwongwanich and F. Blaabjerg, "Mitigation of Interharmonics in PV Systems With Maximum Power Point Tracking Modification," in IEEE Transactions on Power Electronics, vol. 34, no. 9, pp. 8279-8282, Sept. 2019.

[7] C. Moo and G. Wu, "Maximum Power Point Tracking With Ripple Current Orientation for Photovoltaic Applications," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 2, no. 4, pp. 842-848, Dec. 2014.

[8] M. Dhimish, "Assessing MPPT Techniques on Hot-Spotted and Partially Shaded Photovoltaic Modules: Comprehensive Review Based on Experimental Data," in IEEE Transactions on Electron Devices, vol. 66, no. 3, pp. 1132-1144, March 2019.

[9] M. A. G. de Brito, L. Galotto, L. P. Sampaio, G. d. A. e Melo and C. A. Canesin, "Evaluation of the Main MPPT Techniques for Photovoltaic Applications," in IEEE Transactions on Industrial Electronics, vol. 60, no. 3, pp. 1156-1167, March 2013.

[10] R.PFeyman, QED: The Strange Theory of Light and Matter, Princeton University Press, 1985.

[11] H. B. Holl, “Specular reflection and characteristics of reflectedlight,”J. Opt. Soc. Am. 57, 683–690 (1967).

[12] Naseer K Kasim, Ahmed F Atwan, and Fadhil Muhmood Eliewi, “Improve the performance of solar modules by reflectors” The Sixth Scientific Conference “Renewable Energy and its Applications.

[13] M.Raja Nayak, M. Sai Rohith, “ A Review on Optimal Solar Pannel Designs”, National conference on Recent Trends in Electrical Engineering, pp no.7-11, ISBN no. 978-93-88808-57-6, MGIT, Hyderabad, Febraury 2020.

[14] K. Masuko et al., "Achievement of More Than 25% Conversion Efficiency With Crystalline Silicon Heterojunction Solar Cell," in IEEE Journal of Photovoltaics, vol. 4, no. 6, pp. 1433-1435, Nov. 2014.

[15] J. W. Findlay, “Radio Telescopes” IEEE Transactions on Military Electronics, Volume 8, Issue 3, July 1964.pp. 187-198.

[16] T. Tomitani, "A model of optical reflection on rough surface and its application to Monte Carlo simulation of light transport," in IEEE Transactions on Nuclear Science, vol. 43, no. 3, pp. 1544-1548, June 1996.

[17] S. P. F. Humphreys-Owen, “Comparison of reflection methodsfor measuring optical constants without polarimetric analysis,and proposal for new methods based on the Brewster angle,”Proc. Phys. Soc. London 77, 949–957 (1961).

March-April 2020
ISSN: 0193-4120 Page No. 23028 – 23033

[18] Rafic Azzam, "Complex reflection coefficients of p- and s-polarized light at the pseudo-Brewster angle of a dielectric-conductor interface", Journal of the Optical Society of America A 30(10):1975-9 · October 2013.