International Journal of Scientific & Engineering Research Volume 11, Issue 6, June-2020
ISSN 2229-5518

Experimental study of Monofacial Solar Panel

[1]Syed Muzamil, [1]Sonu Ganapathy, [1]Vathsa Rao, [1]Yusuf Hafeez, [2]Vinod R
School of Mechanical Engineering
REVA University, Bengaluru

Abstract— The fossil fuels presently meet all global energy needs to some extent. These Fossil Fuels should be slowly replaced by renewable energy sources in the view of their depletion rates and emission legislation. The usage of renewable energy sources can reduce the pollutant emissions into the atmosphere. Especially the exploration of solar energy can play vital role in developed and developing countries. Solar energy is the most readily available source of energy. Solar energy is an exhaustible source of renewable energy. It is used in the form of solar water pumps, solar lamps, solar water heaters and cooking purpose. Solar energy can be tapped directly (e.g., PV) indirectly as with wind, biomass, and hydropower or as fossil biomass fuels such as coal, natural gas, and oil. Sunlight is by far the largest carbon-free energy source on the planet. India is densely populated and has high solar insolation, an ideal combination for using solar power in India.

Present research work deals with the study on the performance characteristics of solar panels using a bifacial panel. The properties of the solar panels were studied by comparing the monofacial and bifacial solar panels with respect to their efficiencies using a sun stimulator at Premier Energies Pvt Ltd. Hyderabad. The performance characteristics of monofacial solar panels were studied and on comparison with bifacial panels it was found that the bifacial panels were more efficient than the monofacial solar panels.

Index Terms— Solar cell, Solar module

1 INTRODUCTION

Energy consumption is the total energy produced and used by the entire human civilization, it involves all energy harnessed from every energy source applied towards humanity's endeavors across every single industrial and technical sector across the country.

Energy sources can be categorized as renewable & non-renewable energy. Renewable energy are those which are continuously replenished by nature, Earth's heat, Sun, wind, water and plants. Renewable energy technology turns these fuels into usable form of energy. Today we primarily are using Fossil fuels much more rapidly than they are being created, fossil fuels cause pollution that contributes to diseases, using renewable energy is better for the environment and humans.

Solar energy is one of the most consistent sources of renewable energy, Conversion of light energy is based on phenomenon called Photovoltaic effect. There are various varieties of solar cells, the most commonly used cells are Monocrystalline Silicon Solar Cells & Polycrystalline Silicon Solar Cells.

Silicon is the most widely used semiconductor material for constructing the photovoltaic cell. The silicon atoms has four valence electrons. In a solid crystal, each silicon atoms have four valence electrons with another silicon atoms hence creat- ing covalent bonds between them. In this way, silicon crystals get a tetrahedral lattice structure. When light ray strikes on any material some portion of the light is reflected, some por- tion is transmitted through the material and rest is absorbed by the material.

The same thing happens when light falls on silicon crystals. If the intensity of incident light is high enough, sufficient number of photons are absorbed by the crystals and these photons in turn excite some of the electrons of covalent band. These excited electrons then get sufficient energy to migrate from valence band to conduction band. As the energy level of these electrons is in the conduction band, they leave from covalent bond leaving a hole in the bond behind each removed elec- tron. These are called free electrons, which move randomly inside the crystals structure of the silicon. These electrons have vital role in creating electricity in photovoltaic cells. These electrons and holes are called light generating electrons and holes. These light generating electrons and holes cannot pro- duce electricity in the silicon crystal alone. There should be some additional mechanism to do that.

2 LITERATURE REVIEW

[1] In this study the focus was towards getting 50 per cent more output power from an albedo collecting flat panel using bifacial solar cells. Flat panels were made with bifacial back- surface-field silicon cells which were placed between two wooden boards painted dull white paint. The efficiencies of bifacial cells were found to be 15.0% and 12.4% under front and back illumination which was measured at 28-degree incli- nation and a back to front efficiency ratio of 0.94 was calculat- ed. The measurements were made on a bifacial cell of area 5.4 sq.cm surrounded by a 0.5*1 sq. wooden plate which was painted black on both the sides. The panel was faced south and was tilted to 40 degrees latitude of Madrid, Spain. The ratios of bifacial to conventional short circuit currents were

recorded at different time of the day on cloudy days and clear days. With this it was concluded that the bifacial panel is advantageous for both sunny and cloudy climates.

[2] In this study the energy collected by bifacial photovoltaic panels that track the sun were analyzed. A theoretical model was described that calculated the collection of light by both sides of a bifacial panel installed on a one or two axis tracker and placed against a variety of surroundings. The model was verified experimentally and then used to predict the energy collected for a number of cases. The results for two-axis tracked bifacial panels showed that annual back energies of the order of 25% of the front energies could be obtained. This implied that the total (front plus back) annual energy collected by such panels could be 80% greater than that collected by stationary panel.

[3] In this paper, the study was focused on performance of bifacial modules which depends on the location where they are installed and the elevation at which they placed above the ground level. As per the experimental results a low albedo of 0.25, the bifacial gain of ground mounted bifacial modules in less than 30% but when the panels were placed 1m above the ground level with increasing albedo to 0.5 they boost the bifacial gain to 30% more as compared to monofacial. The other factor which effects the efficiency of bifacial solar module is self-shading. Self-shading is caused when the panels are not placed at particular angle, since bifacial modules absorb light from the rare end they should get adequate light to perform effectively. As concluded installing the module east to west with 1m elevation can reduce self-shading and output gain is high.

[4] In this advance application of bifacial solar modules, have conducted an experiment by keeping 2 bifacial lenses at 2 different positions H type steel pillars erected with a pitch of 2500 mm each of size 125 x 125 x 0.22 mm double glass panel. The first setup the panels are positioned from south to north of about 8 modules were used from (M-1 to M-8) and the second is setup from east to west of same 8 modules (M-9 to M-16). Both are placed in the same vicinity and same time of the day both the sub array stations the experiment was conducted, where current v/s voltage v/s power are recorded from each sub array and were tabulated. The result of each sub array is compared with each other and the optimal placement and arrangement is found out from the graphs, by which they conclude that the first setup which was placed in south to north gave a higher efficiency.

3 METHODOLOGY

1.0 Construction of monofacial module

The construction of the bifacial modules was done in two main configurations. The first configuration had 60% packing density and next configuration had 90% packing density. Packing density is degree of compactness so a very compact configuration for the cell type was taken in order to optimize the area efficiency. The higher area efficiency the greater number of cells fit in the module.

- Solar module design
- Solar cell
- Ethylene Vineyl Acetate
- Low Iron Tempered Glass
- Tinned Copper Wire
- Tedlar
- Junction Box
- Room Temperature Vulcanization Silicon Sealant
- Aluminium Frames
- In Production Visual Inspection
- Wet Leakage current test
- Damp Heat Test
- I V Measurement Test
- EVA Gel Content test
- Tabulation and Result

Solar cell

Solar cell converts light energy into electrical energy through PV cell effect. Photons from the sunlight are absorbed by the semiconducting material such as silicon. An array of solar cells converts solar energy into direct current (DC), which is later converted into alternating current (AC) by using an invertor.

Ethylene Vinyl Acetate

Ethylene Vinyl Acetate (EVA) is a co-polymer, it is a high elastic material with great toughness. It as flexible as low-density polyethylene (LDPE), showing tensile elongation of 75 % with a peak melting temperature of 250 F. It is used to keep the cells intact within the frame.

Low iron tempered glass

Anti-Reflective coating (ARC) glass is a technical means to reduce reflection and increase light absorption of solar cell and increase its performance, the anti-reflective coating on a solar cell. Anti-reflective coating on the solar panel glass will improve the light transmittance and therefore increase the overall efficiency of the PV module.

Tinned copper wire

It is an interconnect wire between the cells which has low yield strength and high elongation. This transmits electricity more efficiently.

Tedler

It is a composite-layer film used as covering foil on the backs of solar modules to enhance the longevity of the panels. TPT (Tedler polyester) along with the glass layer on the front side are the key barriers against damaging externalities, most importantly water vapor and dirt. It can make the solar panels to be used more than 25 years in floor, roof, desert, coastal areas.

Junction box

The junction box is an enclosure on the module where the PV strings are electrically connected. A PV junction box is attached to the back of the solar panel (TPT) with silicon adhesive.

Room temperature vulcanization silicon sealant

Silicon sealant are used to seal the frames with the edge trimmed laminates. They seal top structures to the substrate, and are particularly effective in waterproofing process by keeping moisture out the components in which they are used.

Aluminum frames

The anodized aluminum frames give the solar module the rigid strength and support. They form the very frame of the solar panel.

Wet leakage current test
Wet leakage current test is the electrical isolation of the equipment's housing to ensure it can withstand moisture or wetness from outdoor conditions. The module is immersed in a shallow tank until the entire module surface is covered ex- cept for cable entries or the junction boxes which is not de- signed for water immersion. Then a testing voltage is applied for a period of two minutes across the output connectors of the panel.

Damp Heat test

The PV Damp Heat Test is an accelerated environmental aging test that determines the ability of the solar module to withstand long-term exposure to high temperature and penetration of humidity. Damp heat testing can reveal various defects, such as delamination, deterioration of glass surface (AR coat- ing), frame corrosion, metal grid discoloration and junction box attachment and connection failures.

IV measurement tests

IV measurement testing shows maximum power, which is a performance parameter. This test is performed several times before and after the various environmental tests, after visual inspection. The intensity of the solar radiation striking the cell controls the current (I), while the temperature increases of the solar cell reduces the voltage (V). The current-voltage (I-V) curve is generated during the flash test of a solar panel and depicts in a chart the relationship between electrical current intensity (I) and voltage (V).

EVA gel content test

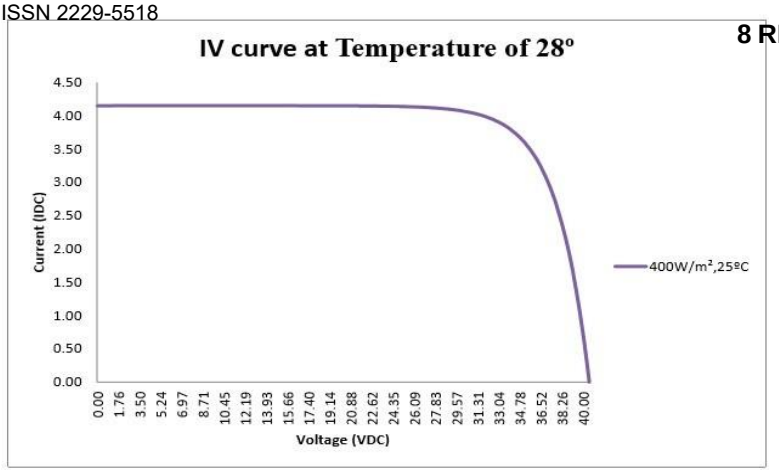
EVA Gel Content test known as a measure of Crosslinking ratio. It is a quality test of solar modules. Gel content of EVA is a measure of the degree of crosslinking in the polymer. Lower gel content can indicate lower degree of crosslinking, which can severely jeopardize the long-term mechanical integrity of solar module

4 LIMITATION OF STUDY

The study of monofacial solar modules shows that it has certain limitions. The module functions effectively only when there is adequate sunlight. The power output of solar module varies with light intensity. The production is not uniform throughout the day. The other factors which effects the effective performance of the module are temperature, tilt angle, self shading,

5 RESULTS AND COMPARATIVE STUDY

The enhancement of power production by utilizing bifacial photovoltaic modules and systems is one of the most promising approaches, and their market is expected to expand tremendously .Unlike conventional monofacial silicon photovoltaic modules, bifacial silicon PV modules are designed to absorb sunlight incident on both the front and back surfaces of cells by adopting grid-type metal contacts for both surfaces. Furthermore, in the configuration of these modules, opaque back-sheets are replaced with transparent back-sheets or glass. A global analysis and optimization of various bifacial module configurations using opto-electro-thermal simulations suggested that a bifacial gain of nearly 30% is achieved under the conditions of a module height of 1 m and an albedo of 50%.Even though bifacial photovoltaic modules are slightly more expensive than monofacial photovoltaic modules, bifa- cial photovoltaic modules produce more power and are suit- able in for all regions and climates compared to monofacial PV modules.



In the above graph, x axis indicates voltage and y axis represents cell current. As the solar cells are connected in series, cell current is constant with the increase in voltage values up to the maximum power point, after which there is a gradual de- crease in current values with increase in voltage values.

6 CONCLUSIONS

The research we conducted provides an overview of the performance characteristics of the monofacial solar panel. The major conclusions arrived from the review are summarized below

- The renewable energy replaces the need for current fossil fuels used for generation of electricity, which cuts greenhouse gasses and helps in sustainable development.
- The power outcome of the monofacial solar panel is directly proportional to the intensity of irradiance striking the panel.
- At an azmutal angle (angle of tilt) of 14.5 degrees the maximum power output is derived.

7 FUTURE SCOPE OF WORK

Solar power will clearly continue to be an essential renewable energy option in the coming decades. The research work can be extended by conducting a performance study on Bifacial solar panels. Further study can be conducted to evaluate effi- ciency improvement of the solar panel by using passive con- centrators and reflector systems.

Bifacial Solar panels currently come with a significant cost premium and in residential setups are unlikely to produce additional power required to justify their price. A study can be conducted on methods on how to make them more cost efficient.

The study of use of passivated emitter and rear cell (PERC) technology to increase energy yields in Bifacial solar panels can be taken up as future work.

8 REFRENCES

1. A. Cuevas, A. Luque "Albedo collecting flat panel using bifacial solar cell", Instituto de Energia Solar, Solar Energy,Vol. 29 No.5.pp. 419-420. October 2009
2. Chin Kim Lo, Yum Seng Lim "Improvement of bifacial solar panel efficiency using passive concentrator and reflector system", International Conference on Renewable Energy Research and Applications, Madrid, Spain, 20-23 October 2013
3. E. LORENZO & M. A. EGIDO "Bifacial Photovoltaic Panels with Sun Tracking", International Journal of Solar Energy, 4:2, 97-107, DOI: 10.1080/01425918608909842
4. Marius Peters & Timothy Michael Walsh "Vertically mounted bifacial photovoltaic modules" Solar Energy 61 (2013) 447-454
5. Xingshu Sun, Chris Deline, Muhammad Ashraful Alam. A global prespective on "Optimization and performance of bifacial solar modules" Applied Energy 212 (2018) 1601–1610
6. M. Ryyan Khan, Amir Hanna, Xingshu Sun "Vertical bifacial solar farms: Physics, design, and global optimization" Applied Energy 206 (2017) 240–248
7. Toshio Joge, lchiro Araki, Kazuhisa Takaku "ADVANCED APPLICATIONS OF BIFACIAL SOLAR MODELUS" 3rd World Conference on Photovoltaic Energy Conversion May 11-IS', 2003 Osnkn, Japan
8. R.Zulkifli, M.A.Alghoul, and Saleem H.Zaidi . Research Article on "Characterization of a Bifacial Photovoltaic Panel Integrated with External Diffuse and Semi-mirror Type Reflectors" International Journal of Photoenergy Volume2013, ArticleID465837. September 2012
9. A. Luque, A. Cuevas, and J. M. Ruiz, "Double-sided n+-p-n+ solar cell for bifacial concentration" Solar Cells, vol.2, no.2, pp. 151–166,1980.
10. T. Joge, Y. Eguchi. Y. Imam, I. Araki, T. Uematsu, K. Matsukuma, "Applications and field tests of bifacial solar modules", Photovoltaic Specialists Conference, New Orleans, 2002, p.1549.
11. Luque A, Hegedus S. Handbook of photovoltaic science and engineering. 2nd ed. Wiley; 2010.
12. Haurwitz B. Insolation in relation to cloudiness and cloud density. J Meteorol 1945;2(3):154–66
13. Luque A, Hegedus S, editors. Handbook of photovoltaic science and engineering, 2nd ed.; 2011