e-ISSN 2320 –7876 www.ijfans.org
Vol.11,S Iss.2, 2022
  UGC CARE Listed (Group -I) Journal

Design & Implementation of a Novel approach for Efficiency Improvement of Solar panels using Solar Concentration with amalgamation of Reflectors & Cooling

Vinod Kumar[1], Dr. Rajeev Ratan[2], Dr. J. V. Desai[3]
[1] Research Scholar, ECE Department, MVN University, Palwal - Haryana(India)
[2] Professor, ECE Department, MVN University, Palwal – Haryana (India)
[3]Sr. Professor, ECE Department, MVN University, Palwal – Haryana (India)

Abstract:

Concentrated photovoltaic technology, often known as CPV, utilises optics like mirrors and lenses to concentrate sunlight on solar cells in order to create electricity. When compared to non-concentrated photo-voltaic, concentrated photo-voltaic have the benefit of requiring a lesser amount of solar cells to generate the same quantity of electricity. In addition to the length of time that PV modules are exposed to sunlight and its intensity, temperature has a significant influence on their performance. High temperatures have a significant negative effect on output power. In this academic paper, the topic of increasing the competence of solar panels via the usage of mirrors & a cooling system is discussed. These indicators are not only affordable but also easy to use and do not need for any extra tools or devices to function properly. CPV, on the other hand, performs well in the presence of intense light so long as the solar cells are cooled by a hotness sink. Therefore, the total efficiency of the solar panel should be improved. Experiments are contrasted in which reflectors were used but there was no cooling present (case a), reflectors were used but there was no cooling present (case b), and reflectors were used but there was cooling present (case c). The equivalent findings from other configurations, which reveal efficiency increases of up to 30 percent in instance (b) & 50 percent in instance (c)

Keywords: Improvements in efficiency, passive cooling, simple mirrors, concentrated photovoltaic, and four-sun technology are some of the topics covered.

I. INTRODUCTION

Energy is now the most fundamental need that humanity has. It makes certain that a better level of life is maintained. In recent years, continuous energy supply for day-to-day consumption has developed into a need for the human race. Electricity is to the economy of any nation what blood is to the body; without it, the economy would be unstable, and it will be impossible to keep it that way. Energy is a key problem in every region of the globe, and governments everywhere are actively searching for new sources of energy as the need for it quickly increases. Due to the fact that non-renewable energy sources are either prohibitively expensive or detrimental to the surrounding ecosystem, their use is destined to be phased out in the not too distant future. Because of this, people all over the globe are gravitating toward renewable energy sources, which are those that can be naturally replenished within a reasonable length of time. Despite the fact that hydroelectric But, it is not available in all parts of the world, while solar has the possible to substitute all procedures of control cohort [1],[13-14]. Solar has the latent to substitute all procedures of power generation .Solar has the potential to replace all forms of power generation [S For thousands upon thousands of years, the sun has provided its services, which come in the form of light and heat. Photovoltaic cells are now the most common way that solar energy is converted into usable electricity.

II. PRINCIPLE OF SOLAR CELL

In order to manufacture solar cells, semiconducting materials like silicon are "doped" with a variety of impurities [7]. This causes solar cell free from electrons (n-type) on one side of the connection, and an extra of hovels (p-type) on the opposite side of the connection as a consequence of the phenomenon. Solar light is composed of photons, which excite electrons in solar cells that are only supposed to move in one way. This leads to the development of electron-hole pairs in the junctions that correspond to them, which in turn produces electricity that may be used by an external circuit.

Under standard circumstances, the voltage produced by a solar cell ranges from 0.5 to 0.65 volts direct current (DC). The efficiency of a photovoltaic cell is the primary factor that determines its current and voltage (power). The amount of light that penetrates to the cell's surface determines the size of the cell, measured in terms of its surface area. The maximum amount of electricity that can be generated from a standard commercial PV panel with a superficial part of160 cm-2 (25 inch-2) is 2 electric energy when the sun is shining the brightest. If the strength is just 60% of its top, it will generate somewhere about 1.2 watts. As a direct consequence of this, intensity has a considerable bearing on effectiveness [8]. Extensive research indicates that there are 2approaches, namely constructions and inert plans, that may be used to increase the output of a PV cell [2- 6]. Because of the high cost of production, passive devices are often used to increase operational effectiveness.

e-ISSN 2320 –7876 www.ijfans.org
Vol.11,S Iss.2, 2022

III. EFFECT OF IRRADIANCE

The standard unit of measurement for it is the watts per square metre (W/m2) an irradiation of one thousand watts per square metre should be received by a solar module under perfect circumstances; but, because of environmental factors, this cannot be achieved in practise. The physical site, the angle of the sun with respect to the solar panel, and the amount of energy that is lost due to likenesses from power sub-divisions, fog, and clouds all have a role in determining the intensity of the radiation. Therefore, a change in the amount of irradiance will result in a change in the amount of electricity that is produced by the solar panel.

IV. TEMPERATURE EFFECT

Conductive resources are made up of unrestricted electrons, about of which are firmly bound to the nucleus of the material. As the intensity of the radiation increases, a greater number of photon packets are absorbed by the panel. This vigour is then taken in by the atoms and electrons, which causes them to collide with one another. As a result, more electrons are emitted from the atoms, which cause the temperature to rise. When the temperature rises, there is a corresponding increase in the amount of confrontation to the movement of current. The competence is also depending on the temperature.

When compared to lower temperatures, the solar panel's output power is reduced when it is subjected to higher temperatures [10]. It is expected that the efficiency of the PV module will decline by 0.5 percent for every degree that the temperature rises beyond the set point. PV modules are commonly produced at a temperature of 25oC (77oF), and they may be operated at temperatures higher than 20oC.

V. COOLING

According to a research that was conducted by Akbarzadeh and Wadowski [15], when the temperature of a solar cell goes from 460 degrees Celsius to 84 degrees Celsius, the performance of the solar cell drops by fifty percent. Therefore, a cooling system that is both effective and efficient is an urgent need in order to enhance the effectiveness of a solar cell and to prevent the cell from degrading or being damaged. There are two ways to cool solar modules: actively or passively. The active system is differentiated from the passive system by the word "active." In order for it to function, it must be connected to an outside source of energy, in contrast to a passive system, which does not need any extra energy source [11-12].

VI. EXPERIMENTAL SETUP

Experimental data (measurements and graphs) gathered from three distinct approaches were used as the basis for the technique that has been suggested for boosting the efficiency of solar panels. This information was collected over the course of three sunny days in April. In this experiment, solar panels made of mono-crystalline silicon semiconductors were used. A solar panel and three mirrors were each given their own slot in a metal frame that was constructed specifically for the purpose.

For the purpose of this experimental method, an active cooling system was used in order to enhance the efficiency of the PV module.

PVC plastic tube through perforations in the lowest was fastened over the frame of the solar panel, which was additional powered by a neoprene tube from aquatic tank full by an electric motor. The solar panel was additional powered by a rubber tube from a water tank full by an electric motor. A solar panel in the middle of the structure is illuminated by reflected light from a top mirror, two side mirrors, and a centre mirror. This method is also known as the four suns technique.

This inquiry uses three different approaches, which are as follows: a) no mirrors, no cooling; b) mirrors, no cooling; and c) mirrors, cooling.

VII. RESULT

Table 1: change in current, voltage and power w.r.t concentration and cooling

Voltage (Volts)	**Current (Amp.)**	**Power (Watts)**	**Concentration**
11.97	1.90	22.74	Without
14.02	1.91	26.77	1 mirror
14.41	1.92	27.66	Plus cooling
15.10	1.93	29.143	2 mirrors
15.49	1.93	29.89	Plus cooling
15.70	1.94	30.48	3 mirrors
15.90	2.21	35.13	Plus cooling

Table-1 gives information on how the presentation measurements of a solar cell vary with regard to changes in ecological variables, which in this instance are step-by-step variations in concentration and cooling. The chart may be found here. The testing results make it abundantly evident that the solar panel does not even generate the power specified for it, which is 22.77 watts, when it is not subjected to concentration. Simply attaching 1 mirror to it results in an increase in output power of roughly 26.77 watts. In a similar way, an increase in concentration and cooling leads to an increase in power output.

Table-2: Irradiance with and without mirrors

Time (Hrs.)	Without Mirror Irradiance (W/m2)	With Mirror Irradiance (W/m2)
8:30 Hrs.	250	350
9:00 Hrs.	300	700
9:30 Hrs.	400	1000
10:00 Hrs.	650	1350
10:30 Hrs.	750	1700
11:00 Hrs.	800	1900
11:30 Hrs.	900	2100
12:00Hrs.	1000	2200
12:30 Hrs.	1100	2225
13:00 Hrs	1200	2250
1330 Hrs.	1150	2000
14:00 Hrs.	850	1700
14:30 Hrs.	700	1500
15:00 Hrs.	650	1200
15:30 Hrs.	500	750

Table-2 gives the irradiance at different time, at 8:30 am, the irradiance without mirror is 250W/m2 and with mirror is 350W/m2. As per experiment the irradiance is increases up to 1:00 pm, which is 1200W/m2 without mirror and 2250W/m2 with mirror respectively. After that irradiance is decreasing up to 3:30pm, which is 500W/m2 without mirror and 750W/m2 with mirror respectively as per experiment.Fig.1 shows irradiance at different time with and without mirror.

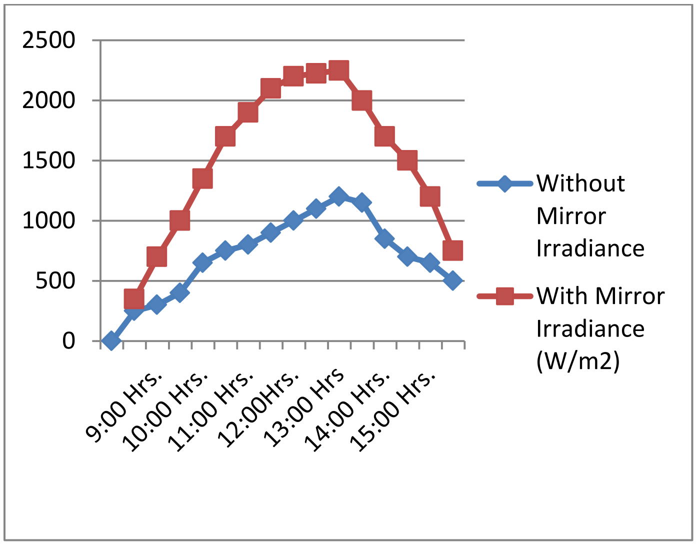

Fig. 1: Hourly changing Irradiance (W/m2)

Table-3: Hourly comparison of three methods

Time (Hrs)	**Without mirrors and cooling(W)**	**With Mirrors and without cooling(W)**	**Three mirrors plus cooling(W)**
8:00 Hrs.	20.17	26.12	23.7848
8:30 Hrs.	21.01	27.58	25.7756
9: 00 Hrs.	21.60	29.00	27.5125
9:30 Hrs.	22.21	29.40	31.4433
10:00 Hrs.	23.05	28.50	33.1758
10:30 Hrs.	24.63	29.05	35.6399
11:00 Hrs.	25.44	31.81	37.4188
11:30 Hrs.	25.91	31.91	38.6444
12:00 Hrs.	26.30	32.26	38.709
12:30 Hrs.	26.40	34.20	39.46
13:00	24.44	30.94	36.5450

Hrs.			
13:30 Hrs.	23.26	30.45	33.2936
14:00 Hrs	21.22	30.34	31.0969
14:30 Hrs	20.81	28.87	28.6212
15:00 Hrs.	20.02	28.56	27.0064
15:30 Hrs.	19.09	28.10	26.3455

Table-3 shows the comparison of three methods, At 12:30 PM all the three methods have maximum efficiency. With mirrors and without cooling method is to generate 29.5% more than the without mirrors and cooling i.e. first methods. Similarly at the same time three mirrors plus cooling method improves the solar panel efficiency 49.5% more than the first method

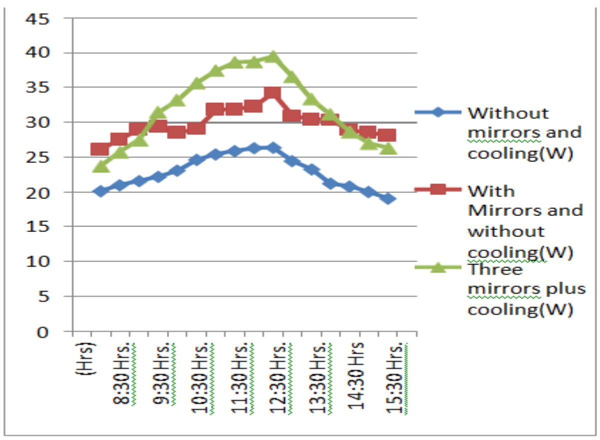

Fig.2: Time-varying performance of solar modules under three different conditions for a) No mirrors, no cooling

b) With mirrors, no cooling c) With mirrors, and cooling

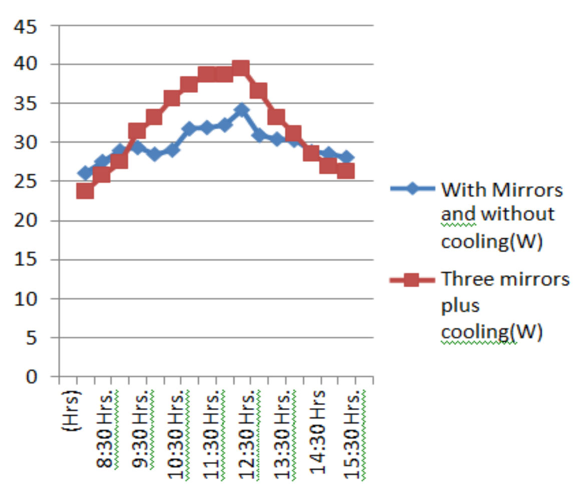

Fig. 3: Percentage improvement in solar panel efficiency using a) Three mirrors without cooling b) Three mirrors plus cooling.

DATA ANALYSIS

A. *Without mirrors and without cooling*

Though most individuals from all over the world used this method a few years ago, it is now nearly obsolete due to its inefficiency. The curve in fig.2 clearly illustrates that the output power of a solar panel without mirrors or cooling is not only less than the other two techniques, but also less than the rated power. Most of the time, solar irradiance in this situation is around 750w/m2.

B. *With mirrors and without cooling*

Solar panel efficiency can be improved by increasing solar irradiation on the panels. As we can see from the graph, irradiance changes with time, hence output power is heavily influenced by it. Because the world only has one sun, reflecting mirrors can also be called the sun. Solar radiation from four suns is striking on the solar panel in this example, and the results are encouraging. The related output characteristics of this method are shown in the second curve of fig.2 and the first curve of fig.3. Figure 2 shows an increasing tendency from 8:00 AM to 10 AM, but a declining trend from 10 AM to 10:30 AM

This is because the irradiance received is at its highest during these peak hours, therefore the temperature effect takes over and power output drops. Collisions between atoms and electrons obstruct current flow, raising resistance, which finally leads to an increase in temperature and a decrease in output power.

The effectiveness of the solar panel during these hours is lower than during other hours of the day, but it is still better than utilizing solar panels without mirrors and without cooling, as shown in Fig.3.

e-ISSN 2320 –7876 www.ijfans.org
Vol.11,S Iss.2, 2022

This strategy increased efficiency by approximately 30% on average.

C. With mirrors and with cooling

The results of this method were encouraging, as its output power was significantly greater for around 6 hours of the day than the method described in section B. The production is less than the second way only for one hour in the morning from 8:00 AM-9:00 AM and one hour in the evening from 2:30 PM-3:30 PM, as shown in fig.2. Because cooling began at 8:00 a.m. and finished at 3:30 p.m. for this method, the power and efficiency were poor. As previously described in previous sections, when electrons absorb enough thermal energy, they smash with each other and with other atoms, releasing free electrons. During these hours, the solar panel receives the same amount of solar energy from the sun as the section B method**.** But the cooling method removes some of the heat energy from the solar panel, making it less efficient than using a mirror and just utilizing the cooling method for three hours. This approach was approximately 19.5% more efficient than the second one and 49.5% more efficient than the first.

CONCLUSION

The results of the experiment to improve solar panel efficiency utilizing mirrors and cooling were extremely positive. Mirrors with cooling are more efficient than the other two methods, with 49.5 % efficiency. The output power of a simple solar panel without mirrors was 26.4 watts; On the other hand, the output power of the solar panel with mirror and cooling function was 39.46 watts. So, with this strategy, instead of buying new solar panels, you can get 49.5% more power from the same solar panels.

RECOMMENDATIONS FOR THE FUTURE

The last strategy was the most effective of the three, but it still has to be improved. Following these tips will increase efficiency beyond 49.5%.

Solar panels stop the cooling in the morning and evening. This will undoubtedly result in increased output power. The entire experiment was conducted without using the maximum power point tracking technique (MPPT). As a result, these two strategies can be combined to increase efficiency.

Reference:

- F. Kreith and D. Y. Goswami, Handbook of Energy Efficiency and Renewable Energy. CRC Press, Taylor & Francis Group,2007.
- M.Brogren,“Opticalefficiencyoflow- concentratingsolarenergy systems with parabolic reflectors,” Doctoral thesis, 2004

- R. M. Swanson, "The promise of concentrators," Progress in Photovoltaics: Research and Applications, vol. 8, no. 1, pp. 93– 111, 2000.
- Luque and S. Hegedus, Handbook of Photovoltaic Science and Engineering. John Wiley & Sons,2011.
- R. B. Pettit and E. P. Roth, Solar Mirror Materials: Their Properties and Uses in Solar Concentrating Collectors. Solar MaterialsScience,1980.
- Luque, G. Sala, and I. L. Heredia, "Photovoltaic concentration at the onset of its commercial deployment," Progress in Photovoltaics: Research and Applications, vol. 14, no. 5, pp. 413–428,2006.
- S. Guha, "Manufacturing technology of amorphous and nanocrystalline silicon solar cells", Physics of Semiconductor Devices, IWPSD 2007.
- V.L. Dalal,"Design considerations for high-intensity solar cells", Journal of Applied Physics (Vol.48 , Issue: 3)1977
- C.H Lin and W.L Hsieh, "Optimization of Photovoltaic Penetration in Distribution Systems Considering Annual Duration Curve of Solar Irradiation", Power Systems, IEEE Transactions on (Vol.27 , Issue: 2) 2012.
- T. Kozak and W. Maranda, "Influence of ambient temperature on the amount of electric energy produced by solar modules" Mixed Design of Integrated Circuits & Systems, MIXDES '09. MIXDES-16th International Conference.2009
- P. Prudhvi and P. ChaitanyaSai, "Efficiency improvement of solar PV panels using active cooling" Environment and Electrical Engineering (EEEIC), 11th International Conference.2012.
- G. LAIF " Design, Analysis and Control Methods" Active Solar Systems, MIT Press.1993.
- T. Yoshino et aI., "Power Electronics Conserves the Environment for Better Future", Proceedings of PESC2008, pp. XCIX-CIV, June2008.
- T. Yoshino et aI., "MW-Rated Power Electronics for Sustainable and LowCarbon Industrial Revolution", Proceedings of ISIE201O, pp. 3811- 3816, 4- 7 July2010
- A. Akbarzadeh and T. Wadowski, "Heatpipe-based cooling systems for photovoltaic cells under concentrated solar radiation,"*Applied Thermal Engineering,*