SIMPLIFIED MIRROR TECHNIQUES FOR IMPROVING SOLAR CELL PERFORMANCE

[1]Maghar Singh , Dr Geena Sharma[2]

[1]Mtech in Power electronics and drives, [2]Associate Professor & Head of DepartmentDepartment of electrical engineering
Baddi University of Emerging Sciences & Technology, Baddi , Himachal Pradesh

Abstract:
Solar energy has a very promising future as a tool for mitigating the effects of climate change. Because solar energy has the benefit of producing a relatively low level of greenhouse emissions, it is likely that it will eventually replace a significant proportion of fossil fuels. The purpose of this study is to create more electricity by employing mirrors to collect more solar radiation as well as sunlight to Photovoltaic cells. This improves the amount of energy that can be generated by a certain region of solar cells. The purpose of the study is to evaluate whether or not a simplified mirror technique can improve the performance of a solar cell, to determine the aspects of a solar cell that can be improved using simplified mirror techniques, and to confirm that the solar cells' performance has improved as a result of the simplified mirror techniques. The use of reflectors that are flat in form allows for an extra level of sunlight concentration to be achieved on the surface of the solar panel. It is also possible to utilise reflectors with a parabolic form in this scenario; however, the production cost of these reflectors is more than the manufacturing cost of flat reflectors, hence this alternative strategy was not pursued. This particular sort of mirror is only effective in a certain location to concentrate the sunlight onto a more condensed region that faces in a particular direction. This might cause the temperature of the solar panel to increase, necessitating the need for an additional cooling device. It reaches its peak during the midday hours, which makes sense given that this is when the radiation is at its highest.

Keywords: Solar panel, battery, mirror technique, PV panels, Solar photovoltaic systems, Solar PV plants, solar PV systems, energy storage.

1. Introduction

Solar power is a renewable energy source that can be used practically year-round and is free of environmental impact. The amount of solar energy the Earth receives in one hour is enough to power the whole planet for a year, according to some estimates. Similarly, striking is solar energy's capacity to slow climate change. Due to its low carbon footprint, solar power has the potential to displace a lot of traditional energy sources. During production, conversion devices only release a trace quantity of carbon dioxide. There is a wide variety of ways in which solar energy may be put to use, from illumination to heating to distillation to the creation of fuels. Wherever it would be impossible to extend transmission and distribution lines, solar panels are a common sight, producing electricity for nearby residents. The sun's irradiation may be converted into usable electricity by a process known as the photovoltaic effect, which is carried out by solar panels. The amount of solar irradiation and temperature both have an effect on the voltage that is produced by a solar panel. Because the irradiation from direct sunlight and the temperatures both fluctuate, the output voltage changes as well. Many pieces of electrical and digital equipment cannot be directly linked because the voltage that is generated is constantly fluctuating and increasing and decreasing (Srisailam, Srihari and Babu., 2015). As a consequence of this, ripping tools that have DC-DC boosts and consistent output voltages are required. The voltage of the electrical current generated by solar power will be increased by the raised converter until it meets the specifications for the voltage needed by electronic devices. Because it is designed to work with AC electrical appliances, the device calls for an extra AC-DC inverter, which is responsible for converting the standard DC voltage into AC voltage. Dual Electric Power Processing Stage System describes this arrangement of components. In this stage between the boost converter and the inverter, we utilise the battery to conserve voltage, which will let the tool run far more efficiently. A compact solar panel equipped with optic lenses, such as a replicate or parabolic lens, might be used to provide the necessary voltage for this purpose. In order to increase the solar power electrical output of a given work, optic-enhanced lenses, such as mirrors or parabolic lenses, are often used (Arshad et al., 2014). obtaining electricity in order to generate volt quality. With the help of such an enhanced lens, we are able to get a significant output voltage from a relatively modest amount of solar power electricity. Concentrated photovoltaics have the ability to harvest solar energy even during times of low irradiance from the sun, which is something that is not very achievable with traditional photovoltaic panels. The purpose of this study is to enhance electricity production from a given area of PV panels by employing mirrors to gather more of the incident solar irradiance and direct sunlight to qualifying PV modules. There is a 12V (5W) solar panel, a 12V (1.3Ah) rechargeable battery, a DC relay, and LED lights that make up the system (Kieth., 2008). The sunlight is converted into energy, which is then stored in a battery. Diodes have been used to create a one-way flow of electricity. This implies that the solar panel is the sole source of electricity for the battery. As soon as the battery is full, the charging process is terminated immediately by cutting power to the device. In order to maximise the solar panel's power output, we have installed mirrors on both sides of it.

1.1 Background

Innovations in technology sparked the Industrial Revolution in the 19th century. There has never been anything like the century's surge of innovations. Using previously discovered materials like coal and oil was an integral part of several of these discoveries. No thought was given to how the creator or future generations would be harmed by the waste of these natural riches. Recent years have seen remarkable growth in the economy's reliance on coal and oil, both of which have significant negative impacts on the environment (Tandale and Mohite., 2017). Carbon dioxide and other gases are released into the atmosphere when fuel is burned, causing harm to the environment. New ways of thinking about energy technologies are needed now more than ever. Renewable resources, such as the sun, the wind, the ocean, and plant matter, are abundant and may be used to offset the effects of everyday garbage. There is no pollution produced by these resources, and the energy they provide is pure and plentiful (Akash et al., 2022). The expansion of the global economy, society, and industry all need a steady supply of energy. Energy is crucial to our survival. Use of energy by people as a proxy for that nation's level of development and civilisation. Energy comes in many forms, including but not limited to electricity, mechanical energy, chemical energy, thermal energy, nuclear energy, and so on. Various forms of energy, such as solar, bio, human, mechanical, animal, and kinetic, may be extracted and used. The qualities of energy are varied. At the very least, energy conservation states that "energy cannot be created or destroyed, but its form may be transformed" (Ilangovan., 2014). As the world's population, industrial output, and transportation systems all increase, so too does the need for more and more energy.

The amount of energy that is used in India ranks it sixth on the global scale. We went through 3,182,000 barrels of oil every single day. The demand for coal is 686 million metric tonnes. In 2013, we had a power shortfall of 70,000 megawatts while using 600.6 million kWh of energy. There were about 300 million people in India who did not have access to power. In December 2013, there was a power shortfall of 6,120 MW in south India (Basavaraj et al., 2021). So, what are we going to do for the children and young people who will follow us? Warm greetings and thank you for your interest in renewable energy sources. Solar power is the best option for the weather conditions in India.

Literature Reviews

2.1. Employing a Basic Mirror Method to Improve Solar Cell Performance

According to the specialists who contributed to Tandale and Mohite's study, the primary purpose of this new publication is to reveal one type of improvement that may increase the efficiency of solar cell power in driving load. This objective was determined by the researchers who worked on the study. In this respect, in order to boost the efficiency of solar cells, we make use of optic lenses such as parabolic lenses as well as a simple hand mirror. By using the boost converter, we are able to improve upon the process of improvement and make the output voltage more stable. After the standard end result voltage has been produced, we next put that voltage into a battery that has an input voltage of 12 volts in order to store the energy. The output of the battery is DC volts; thus, in order to power an AC load (such as a television), an inverter, which converts DC volts to AC volts, is needed (Tandale and Mohite., 2017). The inverter takes DC energy as input and transforms it into AC electricity as output; this electricity may then be utilised to power an AC load. Experiments that relied on trial and error were carried out with the recently developed software for increased conversion. This software has an electric power rating of 40 Watts, generates ac energy with a voltage of 12 volts, and functions in regular bail mode at a switching frequency of 20 kHz. The experiments were carried out using the software. The results of the testing reveal that the design that was provided has a performance that is up to the standards expected of it. This kind of study article elucidates a viable approach for enhancing the performance of photovoltaic power panels by making use of a system that is based on mirrors, and it does so by reflecting more sunlight onto the panels. These types of mirrors are not only affordable but also easy to handle, less complexto operate, and do not need any additional equipment or devices in order to perform their functions effectively.

2.2. Enhancing Solar Panel Performance with an Easy-to-Implement Cooling Scheme

The research that was carried out by Jahagirdar, Khot, and Joshi came to the conclusion that the production and effectiveness of photovoltaic systems are dependent on the concentration of natural sunlight. Despite this, temperature also performs a crucial function in the effectiveness of these systems and is one of the most important influences. Because of the significant drop in output that high temperatures bring about, which in turn brings about a fall in the level of effectiveness. It is essential to investigate and investigate various methods for ensuring that the system is kept at the appropriate temperature. Due to the fact that temperature is such a significant factor in determining the quantity and quality of the electricity generated by a solar photovoltaic (PV) system, it is essential to investigate and investigate various methods (Jahagirdar, Khot and Joshi., 2019). The purpose of this research is to figure out how the temperature of solar panels may be decreased while they are operating by employing a cooling mechanism, both on the surfaces of the panels and on the panels themselves. During the course of the experiments that were carried out, it was found that the solar photovoltaic system produces different levels of output power, output voltage, current, and efficiency depending on whether or not it is paired with a cooling system. This discovery was made as a result of the fact that the solar photovoltaic system produces different levels of output power, output voltage, and current.

2.3. Solar Energy Generation in Highly Convective Coastal Areas

According to the conclusions of this research project that was carried out by Emetere, Akinyemi, and Edge, it is essential to take into consideration the local climate while constructing a solar farm that is dependable and operational in coastal areas. Simulations in three dimensions were used so that researchers could learn how minute changes in the values of other meteorological elements influence the amount of irradiance received from the sun. In these simulations, a correlation was established between the surface temperature, the amount of daylight, and the solar irradiation (Emetere, Akinyemi and Edeghe., 2016). This made it possible to monitor solar radiation on a daily basis, with the primary objective of determining the method that would result in the greatest amount of electricity being generated from the solar option in coastal areas. This was accomplished by monitoring solar radiation on a daily basis. The most turbulent characteristics, which exhibited the impact of the weather, occurred during the month of January, which also had the lowest solar brightness owing to the low amount of sunshine hours that occurred during that time of year. A computer simulation was run that modelled the climatic conditions that prevailed in the research area over a period of twenty years, with the intention of demonstrating the systematic influence that weather has on the performance of PV. A hypothetical solar farm was discussed in order to provide a reliable source of power supply. The life expectancy of the photovoltaic module was the primary topic of discussion, which was brought up as a result of the installation of an electronic concentrator pillar (CP). In the description of the graphical and functional model of the solar farm, a significant quantity of information was given.

2.4. Ultrathin Hybrid-Metal Electrodes with Finely Tuned Dielectric Mirrors for High-Performance, Colorful, Semitransparent Polymer Solar Cells

Researchers reveal that polymer solar cells (PSCs) display a one-of-a-kind trait of semi-transparency and colouring in this study by Xu et al. This makes them suitable candidates for usage in applications such as appealing windows since they have these desirable qualities. Polymer solar cells were discovered to have these features (PSCs). For the purpose of this investigation, the researchers constructed reversed semitransparent PSCs by employing high-quality hybrid Au/Ag transparent top electrodes and carefully regulated dielectric mirrors (DMs). With this feature, the consumer may customise their electronic device to their preferred hue (Xu et al., 2017). In addition to this, a thorough chromaticity analysis of the semitransparent PSCs is undertaken, in which they are analysed from both the bottom and the top (mirror). The highest PCE of 7% and AVT of 12.2% are achieved by PSCs with inverted layers that are developed on PTB7-Th: PC71BM and comprise six pairs of DMs. This is in addition to the fact that these PSCs have a semitransparent inversion. In terms of translucent PSCs, their efficiency is among the best ever recorded. It is comparable to 81.4 percent of the PCE produced by similar opaque systems. The successful adaptation of the device design as well as the processing method resulted in the creation of a system with a competitive PCE of 6.4 percent and an AVT of 11.5 percent. This was accomplished by creating a device with a flexible substrate. According to the findings of our investigation, this PCE figure is the greatest value that can be reliably attributed to a flexible semi-transparent PSC.

2.5. Research Gap

The goal of this research is to fill in some of the blanks left by previous studies, such as a global survey of solar power plants that don't exist. In addition, policymakers will be enabled to deploy the optimal photovoltaic innovation for every given area. Second, there hasn't been a recent, complete examination of photovoltaics for power production, which is a notable omission from the literature. To the best of the authors' understanding, no recent study has attempted to bridge the third major research gap: a comprehensive assessment of the effectiveness of the three key photovoltaic innovations and their variations.

2.6. Research Objectives

- To assess simplified mirror technique to improve solar cell performance.
- To identify the factors of a solar cell that gets improved through simplified mirror techniques.
- To verify the performance improvement of the solar cells.

Research Methodology

This study will rely on secondary data gathered from a variety of sources, including research journals, papers, studies, publications, online databases, online libraries, and other sources in order to fulfil the aforementioned research objectives.

3.1. Research Design

In this article, an alternate method for increasing the efficiency of solar panels is presented. This concept was conceived in-house and put to the test. The power, voltage, and current of the solar cell are all recorded at various times and with each distinct configuration, and they are compared with one another. The investigation's findings point to the use of a straightforward plane mirror as the most effective kind of reflector material. Because it is readily accessible in the market and comes at an affordable price, in contrast to the relatively high cost of custom-made reflectors (Suyitno et al., 2020). It has been determined that the traditional mirrors provide the best combination of performance and durability, hence this choice has been selected as the best available alternative. We settled on the static versions of the arrangements when just a few examples were taken into account, and we also attempted the configurations with flat and inclined solar panels at first. The mirrors were positioned such that they were perpendicular to the route taken by the sun as well as parallel to it. When the mirrors were arranged so that they were parallel to the direction of the sun's travel, we found that the output changed a greater amount than when they were arranged so that they were perpendicular to the direction of the sun's journey. In the event of the arrangement being parallel, there is no blockage between the sunlight and the mirrors; in contrast, there is an obstacle in the case of the arrangement being perpendicular, and the output of the arrangements is superior in the case of the parallel arrangement. In the end, we experimented with several configurations in which we merely employed standard solar panels and two mirrors, and we found that the outputs from these systems were more effective.

3.2. Research Approach

The cost-effective construction of the mirror-reflected photovoltaic panels, thorough with an advanced monitoring and cooling

mechanism, was accomplished by making use of raw materials that were readily accessible in the area. In the beginning, the cooling structure was hooked up to the photovoltaic panels. The reflectors that were created to the sizes described before were supported by a frame that was built specifically for the purpose. On a frame that is capable of rotation in both the horizontal and the vertical axis, the reflectors and the panel that contains the cooling system have been placed.
Through the use of a relay, the stepper motor, control system, and control valve were all brought into connection with the power source. The control valve was used to link the intake pipe to the PV panel, as well as the output tubing was attached to the cooling module that was located in the bottom part of the Photovoltaic panels. In order to make it easier for fluid to drain via the circumferential area under the influence of gravitational force, cold water was stored in a reservoir tank that was 1.5 metres above ground level. In order to carry out the experiment, the whole setup was exposed to the sun. At first, tracking using a reflection system was done by measuring data such as open circuit voltage and short circuit current. After that, an opaque cover was placed over the mirror, and data collection was used as the only method of tracking. When the power supply was turned on, the solenoid valve would open, and water would begin to flow through the cooling unit. This would continue until the water's output temperature dropped below 25 degrees Celsius. When the output temperature fell below 25 °C, the computer shut off the control valve and began recording data on the cooling system's performance. At last, the mirror covering was removed for a second time, and data were gathered using a technique called monitoring with reflections with cooling.

Analysis of Study

The data analysis section comprehensively explores the raw data obtained from the research methodology section. Subsequently, both the classification and the research methodology are primary and secondary to effectively conclude the data analysis section.

4.1. Environmental and Economic Benefits of PV Systems

The sun's beams are focused using mirrors, which ultimately contribute to the output of heat. This process is recognised as solar concentration. After then, this heat may be transformed into usable energy. Because of their ability to hold the sun's energy in the form of thermal energy, these technologies are a subset of the SunShot Initiative and have a significant competitive advantage over photovoltaic (PV) cells (Shaaban., 2021). This advantage is due to the fact that these technologies can store the energy of the sun. The many methods that may be used to improve the effectiveness of a photovoltaic battery are described in the following paragraphs:

- In order to boost the overall performance of PV systems, a brand-new solar energy concentrating system that is of the cost-effective mirror reflecting linear focus type has been devised. Standard procedures make low-cost manufacturing possible because they decrease the amount of time and effort required to assemble focusing mirrors, which in turn lowers the cost of labour (Benkaddour, Boulaich and Aroudam., 2022). The temperature of the PV panel will grow as a direct result of the mirror's action, which will cause the radiation intensity over the panel to be raised to a level that is higher than its usual value (Reji et al., 2021). The band gap of semiconductor material will be shrunk if the temperature is increased over 25 degrees Celsius. Because of this, the characteristics of the great majority of semiconductor materials will be altered, which will, in the end, lead to a lower open-circuit voltage and poorer efficiency. The efficiency of photovoltaic (PV) cells suffers a reduction of 0.6 to 0.7 percent for crystalline silicon-based cells and a reduction of 0.35 percent for amorphous silicon batteries whenever the temperature of the PV cells is elevated by one degree Celsius (Mayes., 2021). As a result, a cooling system that is both effective and efficient may be a good response to the challenge of increasing the efficiency of a solar system. The deployment of concentrators, trackers, and cooling systems are all viable choices for increasing output power in a manner that is both cost-effective and resource-friendly. It is now believed that the actual effectiveness of a photovoltaic cell is somewhere in the neighbourhood of 17 percent, despite the fact that its theoretical efficiency might range anywhere from 25 to 30 percent.
- Another way that may be utilised to enhance the effectiveness of photovoltaic frameworks is the utilisation of reflecting mirrors and light concentrators, like concentrator photovoltaics, which is very inexpensive (CPV). Traditional techniques, which are characterised by their low price and relatively simple arrangement of reflecting mirrors, make it feasible to manufacture items at a low cost, which makes the manufacturing process viable (Chan et al., 2022). In this generation of photovoltaic cells, it is generally considered that the conceptual effectiveness of a Photovoltaic panel is somewhere between 25 and 30 percent, while the efficiency of a PV cell in actual use is approximated to be somewhere around 17 percent. By reducing the temperature of the panel with either air or water, it is possible to attain a greater degree of overall system efficiency (Chandrika et al., 2021). This may be accomplished in a number of different ways.
- Tracking the sun is a technique that is very necessary and has the potential to dramatically boost the output of solar panels. To tell you the truth, though, it hasn't garnered all that much attention in recent years. The gathering of the maximum amount of light that may be obtained from the sun is the primary objective of tracing the sunlight (Mezrhab et al., 2022). Studies have demonstrated that it is a very simple technology that may successfully increase the output of solar panel systems by more than twenty percent. However, one of the drawbacks of using this system is that while it is running, a portion of the electrical power that is being produced by the solar panel is lost due to the fact that it is being wasted (Racharla et al., 2021). In addition to using incredibly advanced equipment and having a big number of staff members who have received adequate training, it is essential to keep personnel on a regular basis. Because of these particulars, the cost of initial setup as well as continuous monitoring system maintenance is likely to be significantly increased.

  Other ways to improve a solar cell performance are listed below:

  - There are various kinds of photovoltaic cells, and some of them include a transparent conducting film on the side that is facing the light. This film does two things: it lets light into the active material of the cell, and it collects the charged particles that are produced by the cell. Films that have a high electrical conductance, as well as high transmittance, are used the vast majority of the time in order to accomplish this goal (Rungasamy, Craig and Meyer., 2022). High transmittance and strong electrical conductivity are not traits that must be chosen in opposition to one another. For this reason, the creation of a conducting network or the largest density of conducting nanowires should be chosen with the aim of boosting the efficiency of solar panels.

  - It is possible to considerably increase the efficiency of the cell by first covering the surface of the cell that is responsible for receiving light with nanoscale metallic studs. This will allow the surface to better absorb the light. Because these studs reflect light in a direction that is perpendicular to the cell, the amount of distance that light travels while passing through the cell is significantly increased (Qiu et al., 2021). This leads to an increase in both the amount of current that is produced and the number of photons that are taken in by the cell as a consequence of the process. These are the three fundamental components. The quantity of energy that is wasted is drastically cut down due to the fact that aluminium is the only kind of radiation other than ultraviolet that it can absorb, and it also reflects visible and infrared light. Aluminium has the capacity to deliver a rise in cell efficiency that is equivalent to 22 percent (in lab conditions).
  - An increase in temperature of around one degree inside the solar cell is responsible for a decrease in efficiency of the solar cell of approximately 0.45 percent. Solar panels might have a layer of transparent silica crystal applied to them as a preventative measure to stop the deterioration from taking place (Ismail et al., 2020). The layer of silica behaves as a thermal black body, expelling warmth into the environment in the form of infrared radiation and reducing the temperature of the cell by up to 13 degrees Celsius as a result.
  - The use of antireflective coatings might result in the formation of interference with light waves from the sun, which could have potentially harmful effects. As a direct result of this, the sunlight will be focused onto the photovoltaic. Texturizing the surface of a solar cell, which involves changing the surface in such a way that the light that is reflected hits the surface again, is another strategy that is used to minimise reflection. Texturizing the surface of a solar cell involves changing the surface in such a way that the light that is reflected hits the surface again. Etching and lithography are two techniques that may be used in order to produce these surfaces (Chen et al., 2019). Etching is also an option. In addition to texturizing the front cover, adding a flat surface to the back of the cell is another approach to aid in keeping light within the cell, which eventually results in a longer optical path. This may be done in the same manner as described above.
- Solar cells that are constructed from thin-film materials offer a significant amount of promise in terms of both their cost-effectiveness and their adaptability to technical frameworks and structures that have already been built. Solar cells constructed using these materials do not have the same level of optical absorption as solar cells constructed using bulk materials. This is because the materials are so thin. This problem has been addressed, and steps have been made to address it. Due to the fact that this particular recombination process is the predominant one, it is critical to the effectiveness of these cells for it to be present (Gruginskie et al., 2018). If a thin coating of silicon dioxide is applied as a passivating layer, there is a possibility that recombination will be reduced.

4.2. Control Technology and Power Quality Issues of PV Systems

The percentage of solar energy that is converted into usable power by a photovoltaic (PV) device is referred to as the device's conversion efficiency. This efficiency may be measured in watts per square metre. A solar cell is also known as a photovoltaic (PV) cell in certain circles. It is a key purpose of research to improve the efficiency of this conversion, and it is one of the variables that lead to photovoltaic technologies becoming cost-competitive with conventional sources of energy. It is not possible for a photovoltaic cell to convert the whole quantity of sunshine that falls on it into useful electricity (Zhong et al., 2019). In point of fact, the vast majority of it has already been consumed. The capacity of a solar cell to convert the light from the sun that it has taken in might be hampered by a variety of design factors that are inherent to the solar cell itself. Keeping all of these factors in mind during the design process is the most important step you can take to improve your system's overall efficiency.

- **Wavelength**—Photons, which may be thought of as tiny bundles of energy, are the fundamental building blocks of light. Photons may have their wavelengths and energy set to a wide range of values. The wavelengths of sunlight that are able to travel through the atmosphere and make it to the surface of the planet range from the ultraviolet all the way up to the visible spectrum and then into the infrared. Some rays are reflected from the photovoltaic cell's interface, whereas others travel unobstructed (Simon et al., 2020). This is how solar cells generate energy. The energy of some of the photons that are taken in is turned into heat. This happens with a fraction of the photons. The ones that remain are powerful enough to dislodge electrons from their atomic bonds, resulting in the production of charged transporters and electrical energy.
- **Recombination**—The movement of a "charge carrier," such as an electron with a negative charge, is one of the ways that an electric charge can be conducted across a component that is classified as a semiconductor. Another method that an electric charge may be transmitted via a semiconductor is by the movement of an electron with a positive charge. The term "hole" refers to a specific kind of charge carrier that performs operations that are analogous to those of a positive charge carrier (Ahmed and Bawa., 2019). When a material is lacking one electron, this results in the formation of holes, which behave in the same manner as if the electron were there. When an electron comes into contact with a hole, there is a possibility that the two may reunite forces, and as a result, their individual contributions to the electrical current will be nullified. When an electron comes into contact with a hole, there is a possibility that the two may reunite forces. Direct recombination is a phenomenon that may, under certain conditions, cause the process that leads to the creation of energy in a solar cell to be carried out in the opposite direction. During this process, electrons and holes that have been created

by light make touch with one another, recombine, and subsequently form a photon. It is among the most significant factors that contribute to the occurrence of inefficiency (Malik and Chandel., 2020). In the process of indirect recombination, electrons or holes come into touch with an impurity, a mistake in the crystalline framework, or a functionality. This may be thought of as an imperfection in the crystal structure. Because of this, it is easier for the electrons or holes to recombine, which ultimately leads to the release of their energy in the form of heat.

- **Temperature**—when temperatures are lower, solar cells are able to carry out their activities more efficiently. A rise in temperature brings about changes in the properties of the semiconductors; these changes bring about a little boost in the energy output but a far more substantial reduction in voltage than would be expected from the tiny increase in current (Gomaa et al., 2018). Temperature spikes that are too significant have the potential to cause damage to the cell as well as other components that are housed inside the module, which will eventually result in a decreased lifetime for the device. Due to the fact that the cells are able to absorb and convert the majority of the sunlight that falls on them into heat, efficient thermal management may be able to increase both their productivity and their lifespan.
- **Reflection**—It is possible to improve the performance of a cell by lowering the portion of the light that is mirrored away from the surface of the battery. This will allow light to enter the cell. Untreated silicon, for instance, has the ability to reflect roughly 30 percent of the light that falls on it (Agrawal, Chhajed and Chowdhury., 2022). Anti-reflective coatings, also known as coatings, that minimise reflection, may be quite useful. Textured surfaces can also be of great assistance. A high-performance cell will have an appearance that is either very dark blue or even black.

4.3 Control Technology and Power Quality Issues of PV Systems

The performance of a photovoltaic cell may be conceptualised as the proportion of the quantity of energy it generates to the amount of energy it draws from the surrounding environment, namely the sun. In order to calculate the effectiveness of a solar cell, one must consider not only the effectiveness depends on the photovoltaic cell's temperature but also on the photovoltaic cell's environment (including the spectrum and intensity of sunlight). Because of this, the standards under which efficiency is judged need to be rigorously controlled so that valid comparison can be made between the capabilities of different devices (King et al., 2000). Examining solar panels in standard settings, often referred to as the Standard Test Conditions, is the approach that is used to compute the primary energy output of solar panels. This method is also known as the Standard Test Conditions (STC). When exposed to sunlight with an intensity of 1000 watts per square metre and kept at a temperature of 25 degrees Celsius, a solar panel with a capacity of 250 watts would provide an output of 250 watts of electricity. This would be the same even if the temperature was kept at any other value. Another factor that goes into deciding the overall quantity of energy that will be generated by solar panels is the efficiency of the solar panels themselves (Sato and Yamada., 2019). The efficiency of a panel may be thought of as an indication of how well it is able to transform the sun's rays into usable energy. If the efficiency of a solar panel is 20 percent, then it will convert into usable energy 20 percent of the entire quantity of light that strikes it. More of the sun's energy will be converted into useful power by a solar panel that has a higher efficiency rating. The bulk of solar panels have an efficiency range from 15 to 18 percent, and this is the industry standard.

To measure the effectiveness of the panel, increase the quantity of sunlight that falls on the surface of the Earth at a certain location by the total area of the panel. The term "incident radiation flux" is used to describe the amount of this quantity (in square metres) (Lumb et al., 2013). If, for example, the solar panel has an area of 2 square metres, and it is estimated that the quantity of sunlight that reaches it is 2,000 watts per square metre, then the total amount of electricity that is generated will be 4,000 watts. If the panel is marketed as being capable of generating four hundred watts, then its effectiveness score is twenty percent (four hundred divided by two thousand is 0.2, and 0.2 multiplied by one hundred percent becomes twenty percent). On the other hand, the situations that occur in real life are not necessarily the same as those that take place in STC (Baig Heasman and Mallick., 2012). As a result, the maximum watts that are advertised for a standard panel are almost never really produced by it. For instance, the temperature of the photovoltaic panels has been mysteriously kept at 25 degrees Celsius. The majority of photovoltaic panels have been found to attain temperatures that are twenty degrees Celsius greater than their surroundings. That is to say, if the ambient temperature is 20 ° C., the photovoltaic panel's temperature is likely to be in the 40-degree range.

4.4 Control Technology and Power Quality Issues of PV Systems

A photovoltaic cell's effectiveness is measured by the amount of incident power that is transformed into energy:

$P_{max} = V_{OC} I_{SC} FF$

$\eta = V_{OC} I_{SC} FF / P_{in}$

Where:

Voc is the open circuit voltage.

Isc is the short-circuit current.

FF is the fill factor and

η is the efficiency.

Results

Conclusion

The observation tables each include data obtained from experiments conducted on solar panels of a distinct kind (without or with a double mirror, as specified in the tables above). It is necessary to hold the mirrors at a sixty-degree angle in order to get the highest possible output and level of efficiency. When comparing this figure to a flat solar panel layout, this value improves power by 16.92 percent and increases power by 8.52 percent. It should come as no surprise that the level of power fluctuates often during the day. Since the levels of radiation are at their highest point in the middle of the day, this explanation makes sense. When a tracking system and a cooling system are used together, there is a linear rise in the amount of electricity that is produced. The shape of the curves is almost similar to one another. Radiation and power levels are at their highest point in the middle of the day when the sun is shining. The levels of energy tend to peak about lunchtime, and then gradually start to drop down again in the late afternoon. The panels' capacity to reflect more sunlight leads to an increase in temperature as a direct consequence of their use. As a direct result of this, the voltage in the open circuit drops, and so does the amount of power produced. To put it another way, the tracking and reflection technique is rendered ineffective at noon. The power curve of the tracking and reflection system begins to grow as soon as the temperature starts to decline. The output power was greater than that of any other method when the temperature was controlled at a lower level using a tracking and reflection cooling system. From midnight until sunrise, there was a linear increase in power, and then from midnight to sunset, there was a linear fall in power. The failure of the cooling system occurred at 4:45 o'clock in the afternoon, as can be seen in the photograph. Due to the fact that the intensity varies from day to day, it is impossible to find two figures that are identical in every respect. The amount of power used is reduced when there is fog in the sky.

Solar energy will, for the foreseeable future, continue to have both a bright future and a diverse array of applications from which to pick. This will be the case even further into the future. The principal expenditure, however, that is linked with the use of this technology is much higher. It is possible to enhance the quantity of light collected while at the same time decreasing the cost of SOLAR power by making use of reflectors and solar panels. The findings of the testing and the analysis indicate that using the mirror system results in higher production of power in comparison to situations in which it is not used. According to the findings of the tests that were carried out on the solar panels, the system that makes use of mirrors produces more power than the system that does not make use of mirrors based on the data pertaining to current and voltage. When used for the production of electricity, it is recommended to make use of two mirrors, such as those shown in Setup No. 03, with the mirrors being held at an angle of sixty degrees from one another. Setting no. 3 (Solar Panel with Reflecting Mirror) is preferable to the other settings that we have examined, which is set no. 3 (Solar Panel with Reflecting Mirror) is preferable to the other settings that we have examined, which is set no. 3 (Solar Panel with Reflecting Mirror) is preferable to the other settings that we have examined (flat solar panel arrangement and inclined solar panel arrangement). The productive efforts made in research and design have directly led to a rise in the maximum power output, which has grown as a direct result.

References

1. Adak, D., Bhattacharyya, R. and Barshilia, H.C., 2022. A state-of-the-art review on the multifunctional self-cleaning nanostructured coatings for PV panels, CSP mirrors and related solar devices. Renewable and Sustainable Energy Reviews, 159, p.112145.
2. Agrawal, M., Chhajed, P. and Chowdhury, A., 2022. Performance analysis of photovoltaic module with reflector: Optimizing orientation with different tilt scenarios. Renewable Energy, 186, pp.10-25.
3. Ahmed, O.K. and Bawa, S.M., 2019. The combined effect of nanofluid and reflective mirrors on the performance of photovoltaic/thermal solar collector. Thermal Science, 23(2 Part A), pp.573-587.
4. Akash, S., Satya, S.S., Jagadeesh, S.N.V.D. and Kiran, P.U., 2022. Solar cell efficiency improvement techniques. Int J Recent Dev Sci Technol, 6(1), pp.69-77.
5. Al Masud, M.A., Abedien, M., Arafi, A., Abadin, M.J., Islam, M.R. and Choudhury, M.S.H., 2022. Performance Optimization of Solar Photovoltaic System using Parabolic Trough and Fresnel Mirror Solar Concentrator. International Journal of Integrated Engineering, 14(1), pp.223-231.
6. Alam, S.M.S. and Rahman, A.M., 2016. Performance comparison of mirror reflected solar panel with tracking and cooling. In 2016 4th International Conference on the Development in the in Renewable Energy Technology (ICDRET) (pp. 1-4).
7. Arshad, R., Tariq, S., Niaz, M.U. and Jamil, M., 2014. Improvement in solar panel efficiency using solar concentration by simple mirrors and by cooling. In 2014 international conference on robotics and emerging allied technologies in engineering (iCREATE) (pp. 292-295).
8. Baig, H., Heasman, K.C. and Mallick, T.K., 2012. Non-uniform illumination in concentrating solar cells. Renewable and Sustainable Energy Reviews, 16(8), pp.5890-5909.
9. Basavaraj, G., Das, N., Ray, B. and Alam, F., 2021. PV Cell Output Power Enhancement by Cooling and Reduction of Reflection Losses from Mirror. In 2021 31st Australasian Universities Power Engineering Conference (AUPEC) (pp. 1-6). IEEE.
10. Benkaddour, A., Boulaich, H. and Aroudam, E., 2022. Solar photovoltaic/thermal air collector with mirrors for optimal tilts. International Journal of Electrical & Computer Engineering (2088-8708), 12(3).
11. Bilal, M., Arbab, M.N., Afridi, M.Z.U.A. and Khattak, A., 2016. Increasing the output power and efficiency of solar panel by using concentrator photovoltaics (CPV). International Journal of Engineering Works, 3(12), pp.98-102.
12. Chan, W., Wang, Z., Yang, C., Yuan, T. and Tian, R., 2022. Optimization of concentration performance at focal plane considering mirror refraction in parabolic trough concentrator. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 44(2), pp.3692-3707.
13. Chandrika, V.S., Attia, M.E.H., Manokar, A.M., Marquez, F.P.G., Driss, Z. and Sathyamurthy, R., 2021. Performance enhancements of conventional solar still using reflective aluminium foil sheet and reflective glass mirrors: energy and exergy analysis. Environmental Science and Pollution Research, 28(25), pp.32508-32516.
14. Chen, H.L., Cattoni, A., De Lépinau, R., Walker, A.W., Höhn, O., Lackner, D., Siefer, G., Faustini, M., Vandamme, N., Goffard, J. and Behaghel, B., 2019. A 19.9%-efficient ultrathin solar cell based on a 205-nm-thick GaAs absorber and a silver nanostructured back mirror. Nature Energy, 4(9), pp.761-767.

15. Elsayed, H.A., Sayed, H., Taha, T.A., Alharbi, A.G., Alenad, A.M., Alshammari, B.A., Ahmed, A.M., Mehaney, A. and Aly, A.H., 2021. Simple and efficient design towards a significant improvement of the optical absorption of amorphous silicon solar cell. Journal of Quantitative Spectroscopy and Radiative Transfer, 275, p.107890.
16. Emetere, M.E., Akinyemi, M.L. and Edeghe, E.B., 2016. A simple technique for sustaining solar energy production in active convective coastal regions. International Journal of Photoenergy, 2016.
17. Gomaa, M.R., Mustafa, R.J., Rezk, H., Al-Dhaifallah, M. and Al-Salaymeh, A., 2018. Sizing methodology of a multi-mirror solar concentrated hybrid PV/thermal system. Energies, 11(12), p.3276.
18. Hall, S.R., Cashmore, M., Blackburn, J., Koutsourakis, G. and Gottschalg, R., 2016. Compressive current response mapping of photovoltaic devices using MEMS mirror arrays. IEEE Transactions on Instrumentation and Measurement, 65(8), pp.1945-1950.
19. Huang, X., Han, S., Huang, W. and Liu, X., 2013. Enhancing solar cell efficiency: the search for luminescent materials as spectral converters. Chemical Society Reviews, 42(1), pp.173-201.
20. Husain, A.A., Hasan, W.Z.W., Shafie, S., Hamidon, M.N. and Pandey, S.S., 2018. A review of transparent solar photovoltaic technologies. Renewable and sustainable energy reviews, 94, pp.779-791.
21. Ilangovan, V., 2014. Increase the Efficiency of Solar Panel by using Mirrors. Journal of Solar Energy Engineering, 1(01).
22. Ismail, M.A., Kreshnaveyashadev, A., Ramanathan, L., Idris, M.H., Ananda-Rao, K., Mazlan, M. and Fairuz, N., 2020. Improving the performance of solar panels by the used of dual axis solar tracking system with mirror reflection. In Journal of Physics: Conference Series (Vol. 1432, No. 1, p. 012060).
23. Jahagirdar, G., Khot, P. and Joshi, S.H., 2019. Improving efficiency of solar panel using simple cooling system. Int Res J Eng Technol (IRJET), 6(6).
24. Kieth, J., 2008. Maximizing Solar Panel Efficiency and Output Power.
25. King, D.L., Quintana, M.A., Kratochvil, J.A., Ellibee, D.E. and Hansen, B.R., 2000. Photovoltaic module performance and durability following long-term field exposure. Progress in Photovoltaics: research and applications, 8(2), pp.241-256.
26. Lee, Y.Y., Tu, K.H., Yu, C.C., Li, S.S., Hwang, J.Y., Lin, C.C., Chen, K.H., Chen, L.C., Chen, H.L. and Chen, C.W., 2011. Top laminated graphene electrode in a semitransparent polymer solar cell by simultaneous thermal annealing/releasing method. ACS nano, 5(8), pp.6564-6570.
27. Lumb, M.P., Bailey, C.G., Adams, J.G., Hillier, G., Tuminello, F., Elarde, V.C. and Walters, R.J., 2013. Extending the 1-D hovel model for coherent and incoherent back reflections in homojunction solar cells. IEEE Journal of Quantum Electronics, 49(5), pp.462-470.