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SOLAR CELL EFFICIENCYIMPROVEMENT TECHNIQUES

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ABSTRACT- Due to the depletion of fossil fuels and the rise in pollution, energy from renewable sources is getting a lot of significance. Alternative sources of energy include solar cells. Solar cells have a 24.2 percent practical efficiency. Solar cell efficiency must be prioritized. The approaches for increasing solar cell efficiency addressed in this study. Using a solar tracker, which follows the sun throughout the day to capture the maximum amount of solar energy. The light that strikes the solar cell is not completely absorbed. Only the UV part of the light is captured, which accounts for 4-10% of the solar incident radiation. As a result, absorption should be expanded to the visible and infrared regions in order to improve solar energy conversion. Nanoparticles are deposited on the metal surface to achieve this. The output voltage falls as the temperature of the solar panel rises. As a result, a cooling technique like A Hybrid Photovoltaic/Thermal (PV/T) solar system is one of the most popular methods for cooling photovoltaic panels nowadays is employed. The hybrid system consists of solar photovoltaic panels combined with a cooling system.

Keywords: Solar cells, Fossil fuels, Efficiency, Photovoltaic, Nanoparticles, Solar energy

1. INTRODUCTION

Due to the alarming rate of depletion of conventional energy sources such as petroleum, coal, and natural gas, as well as the environmental degradation and loss of ecosystem caused by harnessing and using these sources of energy, there is an urgent need to invest in renewable energy sources that can power the world efficiently without causing the greenhouse effect. Renewable energy has attracted greater attention as a response to not only the increasing need for energy but also to the problem of poor environmental conditions as a result of the increase in human population and industrialization. Solar energy is a type of renewable energy that is finding more and more uses.

Solar cell plates are currently installed using largely fixed installation methods that are not necessarily perpendicular to the sun. As a result, solar cell plates are unable to absorb the greatest amount of sunlight, lowering photoelectric conversion efficiency. This work proposes the creation of an autonomous tracking mechanism for the sun, which can keep the solar cell plate perpendicular to the incident sunlight at all times. Outside, the surface of solar panels was easily covered by a thick layer of dust, which reduced photoelectric conversion efficiency and even damaged the device. This study proposes two strategies for resolving the issues. A sun tracking system with two axes was created. To keep the sunlight perpendicular to the solar panels, the system used a combination of sun-angle tracking and photoelectric tracking at different periods. The tracking system is designed in such a way that it tracks the sun on a single axis (azimuth angle) or two axes (azimuth and altitude angles).

The solar panel is focused on by low-cost mirrors, lenses, and light concentrating concentrators. More electrons are produced as a result, increasing the solar panel's power output. The simple light tracking system ensures that the greatest amount of light reaches the mirrors, lens, and light focusing concentrators, before falling on the screen. The downside of this solution is that it raises the panel's temperature, lowering the open-circuit voltage in the process (Voc). To optimize PV module performance, an appropriate cooling system, such as a micro heat pipe array, must be installed.

Anti-Reflection Coating plays a very important role in improving the efficiency of solar cells. Anti-Reflection coating is specified by either the maximum allowable reflectance at a single wavelength or by the average allowable reflectance over a specified wavelength anti-reflection coating intended for a single wavelength range or a single angle of incidence and very high performance can be obtained less than 0.1% reflectance per surface at visible wavelengths on glass substrates. A single layer of a thin film of thickness around 100nm of Silicon Dioxide (SiO_2) and Titanium Dioxide (TiO_2), increases solar cell efficiencies by 3-4% and a triple-layer coating can improve its efficiency by 39-40%. The reflectance of solar cells can be reduced up to 3.2% by using anti-reflection coating. So, multilayer coatings of SiO_2 and TiO_2 can be used for high conversion of the solar spectrum into electrical energy.

The most significant drawback of solar cells is that they do not absorb all of the light that strikes them. Only the UV part of the sunlight is captured, accounting for only 4-10% of the solar light incident. As a result, absorption should be expanded to the visible and infrared regions in order to improve solar energy conversion efficiency. Nanoparticles are deposited on the silicon surface to accomplish this. Because silicon has a smaller bandgap, nano metals are coated on the silicon substrate utilizing hot carrier cells and multiple junction solar cells to increase the capture range.

1.1 PRINCIPLE OF SOLAR CELLS:

Semiconducting materials, such as silicon, are doped with various impurities to form solar cells. On one side of the junction, this results in an unequal distribution of free electrons (n-type) and an overabundance of holes (p-type) on the other side. Solar light contains photons, which excite loosely bound electrons in solar cells that are meant to flow only in one direction, resulting in the formation of electron-hole pairs in corresponding junctions and the generation of electricity in the external circuit. Under no load and open-circuit conditions, a typical solar cell produces 0.5-0.6 volts DC, regardless of size. A PV cell's current and voltage rating are mostly determined by its efficiency and size (surface area), and is related to the intensity of light striking the cell's surface. For example, under peak sunlight conditions, a typical commercial PV panel of surface area 160 cm-2 (25 inch-2) will produce 2 watts of peak power. If the intensity is 60 percent of peak it will produce about 1.2 watts. So intensity adds a lot to efficiency. Extensive research shows that the output of a PV cell can be increased by two methods: fabrications and passive devices. Passive devices are used widely to enhance efficiency as fabrication is an expensive one.

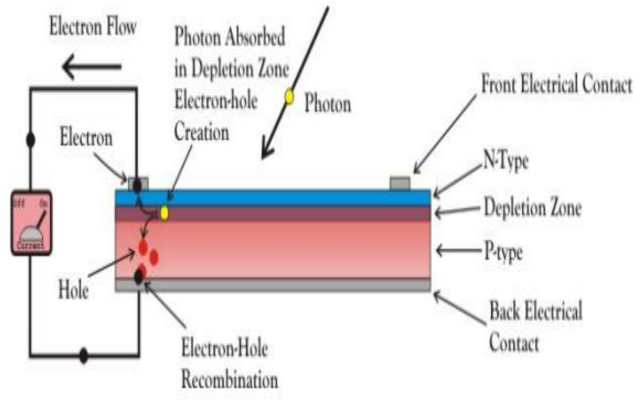

Fig-1: Principle of Solar Cell

2. METHODOLOGY:

2.1 SOLAR TRACKING:

The approach utilised in this experiment is simply the tracking of the sun. Using a concentrator or simple reflecting mirrors is another way to improve the output of the PV module. We shall use commonly used reflecting mirrors to increase the performance of PV modules in this research. Another option to improve performance is to use a cooling solar panel, which has been briefly discussed below. The following are detailed overviews of sun-tracking, light reflection, and panel cooling technologies for performance enhancement: I. The Sun's Tracking Solar tracking is a significant way for increasing the output of solar panels. But it hasn't gained a lot of traction. The purpose of sun tracking is to get the most quantity of sunlight possible. Experiments have revealed that it is a very easy and effective approach to increase the yield of solar panel systems by over 20%. The disadvantage of this technology is that it wastes some of the electric power generated by the PV panel while it is functioning. It necessitates the use of complex machinery and well-trained workers, as well as the daily maintenance of employees. These particulars tend to raise the cost of setup and tracking system upkeep. Another disadvantage is that if the system fails in remote areas of the country, such as Pakistan, it will be difficult to find competent professionals to do the necessary maintenance or repair. If a fault occurs in the circuit and the solar panel is positioned towards the west before noon, the solar panel's output will drop dramatically. As a result, the PV solar system will be unable to deliver even 24% of its rated output power at midnight.

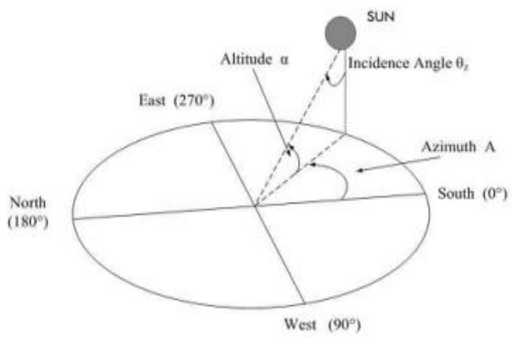

Fig-2: Tracking of sun

Concentrated and Dispersed Light Reflection: Light reflectors that are both concentrated and distributed tend to reflect both intense and diffused sunlight. This is a convenient way that greatly increases the output of the PV module, which is especially useful on bright days. Furthermore, because of the strength of thrown back radiation on specific portions of the panel, it tends to decrease the risks of hot spots developing, which not only improves the performance but also increases the lifetime of PV modules. It is simple to stand it erect, because to its low cost and light weight. Another disadvantage is its mechanical strength; dispersed reflectors are frequently damaged by severe winds. A Variety of Cooling Locations Because the panel surface becomes heated as a result of the additional light radiation, it requires rapid cooling for optimal performance. Cooling the panel could be done from either the bottom or the top. In this design, to avoid extra cost system has been placed in a site where natural air could cool it.

Reflecting Mirrors: Light reflection through mirrors is the most simple and effective method of light reflection. The performance of the PV panel system is improved by reflecting light over the solar panel, which increases output currents and nominal voltage. According to the field data, the improvement in output current by the panel after using the reflecting plane mirror was more than the tracking of the sun. Second, plane reflecting mirrors are fairly inexpensive and widely available.

2.1.1 Advantages:

When compared to modules installed at a fixed angle, solar trackers can boost electricity generation by around a third, and some say as much as 40% in specific areas. When the modules are continuously changed to the ideal angle as the sun traverses the sky, the

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conversion efficiency of any solar application is improved.

2.1.2 Disadvantages:

The addition of a solar tracking system necessitates the addition of extra equipment, moving parts, and gears, all of which will necessitate routine maintenance and the repair or replacement of broken parts. When a solar tracker system fails when the solar panels are at an extreme angle, the production loss until the system is repaired might be significant.

2.2 CHOOSING PROPER NANO METAL:

For a significant amount of light to be absorbed in the active layer, the right selection of metal nanoparticles is crucial. Ag and Au nanoparticles are the most commonly utilised to efficiently support surface plasmon resonance. Aluminium nanoparticles sustain surface plasmon reference more effectively than other noble metals, and they are also less expensive. The corrosion and wear resistance of the aluminium nanoparticle coating increases the solar panels' mechanical strength. The nanoparticles are designed to scatter light throughout the solar cell's whole surface. Nanoparticles like aluminium are the finest choice for the solar cell's construction since they have a large scattering cross-sectional area.

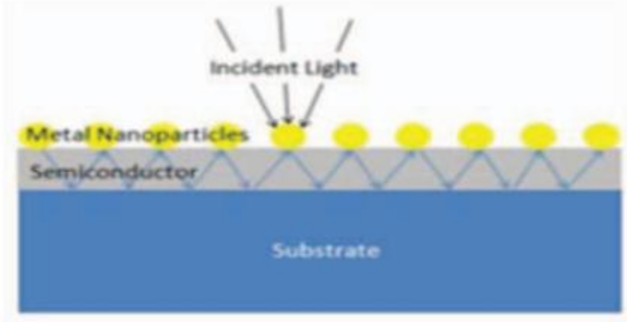

Fig-3: Nano-metal deposition technique

2.3 COOLING TECHNIQUES:

Due to intense sun radiation and high ambient temperatures, photovoltaic panels (PV) become overheated. The efficiency of the panels is reduced when they are overheated. The optimal P–V properties of a solar cell for temperatures ranging from 0 to 25 degrees Celsius. The P–V characteristic is the relationship between the solar cell's electrical power output P and the output voltage V, while keeping the solar irradiance E and module temperature Tm constant. As the temperature of the solar cells rises, the maximum power output drops. This suggests that heating the PV panels can have a major impact on their output.

There are some liquid based cooling techniques like water spraying, forced water circulation, liquid immersion etc. By using water spraying technique maximum of 20℃ temperature can be reduced and it is very efficient simple process. By using forced water circulation technique $20-30$℃ temperature can be reduced and in this technique there will be very efficient reuse of water. By using

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liquid immersion technique which is highly efficient and eco-friendly 40℃ temperature can be reduced.

It is concluded that the cooling system could solve the problem of overheating the PV panels due to excessive solar radiation and maintain the efficiency of the panels at an acceptable level by the least possible amount of water.

2.4 ANTI-REFLECTION COATING (ARC):

Solar energy is captured and turned into electricity when light reaches the silicon cells. Because bare silicon has a high refractive index, more than 35% of incident light is scattered away from the panel's surface before being converted to useful energy. Texturing and anti-reflection coatings (ARC) on the surface help to reduce reflection. Solar cells have anti-reflection coatings similar to those found on camera lenses and other optical equipment. They are made up of a thin layer of dielectric material with a specific thickness that causes interference effects in the coating to cause the wave reflected from the top surface of the anti-reflection coating to be out of phase with the wave reflected from the semiconductor surfaces. The destructive interference of these out-of-phase reflected waves results in zero net reflected energy. Solar panels with anti-reflective glass coating capture more light and hence increase their efficiency. The coating reduces light reflection by 75% and increases power production by 3%, which may seem insignificant, but it's the largest improvement for any anti-reflective coating to yet, and this type of improvement can make a tremendous difference when applied to a large number of solar panels. To coat a solar panel, a liquid solution containing silicon dioxide is applied to the sheet of glass that protects the solar cells, then heated to room temperature, transforming it into a porous, reflection-dulling layer of glass. This coating could be much easier and less expensive to apply because it is heated at room temperature rather than at a high temperature (about 600 degrees Celsius).

3. EXPERIMENTAL SETUP:

3.1 Experimental setup for Solar Tracking System:

The main goal of this project is to design a very precise solar tracker. The project is divided into two parts; hardware and software. The main constituents of the tracking system are shown in Figure4. Hardware parts are generally composed of solar panels, two-DC motors with gearbox, LDR sensor module, and electronic circuit. The software part represents the thinking behaviour of the system, that is how the system acting under several weather conditions.

LDR is a resistor whose resistance decreases with an increase in light intensity. This four LDR are placed on a circular plate and separated by 90 ° space rotation through perpendicular rectangular plastic sheets.

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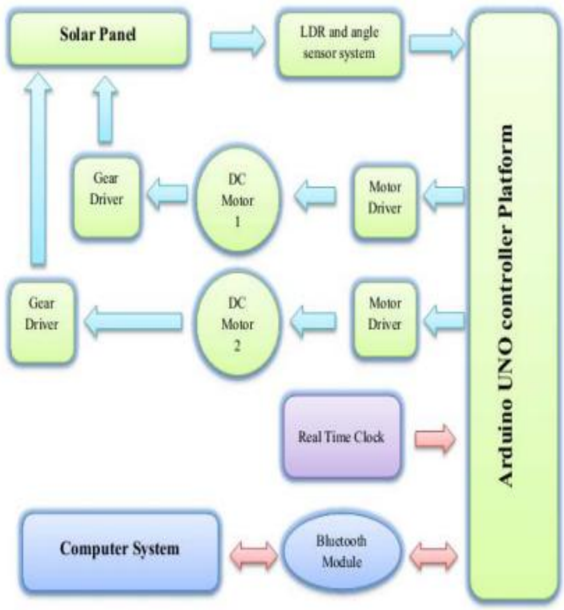

Fig-4: Mechanism of Solar Tracking System

3.1.1 Effect of Irradiance: The efficiency of solar cells is greatly affected by the amount of solar irradiance. It is one of the most dynamic factors which change the solar array performance. It is a measure of the amount of solar radiation from the sun striking a specific surface. It is commonly expressed in watts per square meter (W/m^2). Irradiance depends on geographical position, angle of the sun to solar panel, and amount of energy wasted by reflection from dust particles or fog or clouds. Therefore, the change of irradiance means a change in output performance of the solar panel.

3.1.2 Effect of Temperature: Conducting materials consist of free electrons and some electrons are held tightly by the nucleus of atoms. When irradiance increases, more packets of photons strike the panel and this energy is absorbed by the atoms and electrons and they collide with each other emitting more electrons from the atoms and thus raising the temperature. An increase in temperature leads to an increase in resistance to the flow of current. Efficiency is also dependent on temperature. At high-temperature output performance of solar panels reduces as compared to a lower temperature. According to estimation for every degree rise in temperature, the efficiency of the PV module decreases 0.5 percent. PV modules are usually manufactured at 25o C (77o F) and can be operated above 20℃.

4. APPLICATIONS:

Solar cells are applicable in remote locations. It is not always cost-effective, convenient, or even possible to extend power lines to locations where electricity is needed. PV can be the solution—for rural homes, villages in developing nations, light houses, offshore oil platforms, desalination plants, and remote health clinics.

Solar cells can be used as stand-alone power. In urban or remote areas, PV can power stand-alone devices, tools, and meters. PV can meet the need for electricity for parking meters, temporary traffic signs, emergency phones, radio transmitters, water irrigation pumps, stream-flow gauges, remote guard posts, lighting for roadways, and more.

Solar cells are used as power in space. From the beginning, PV has been a primary power

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source for Earth-orbiting satellites. High-efficiency PV has supplied power for ventures such as the International Space Station and surface rovers on the Moon and Mars, and it will continue to be an integral part of space and planetary exploration.

Solar cells are applicable in transportation. PV can provide auxiliary power for vehicles such as cars and boats. Automobile sunroofs can include PV for onboard power needs or trickle-charging batteries. Lightweight PV can also conform to the shape of airplane wings to help power high-altitude aircraft.

5. FUTURE SCOPE:

In solar energy conversion, nano-metals, transition metal nitrides, quantum dots, organic dyes, and polymer nanocomposites will all play a key part. One of the unique solar energy conversion ideas will be a space-based nano pack. The energy is sent and received in the earth utilising Laser technology, resulting in a higher conversion rate. Solar hybrid power will generate more electricity. As there will be the depletion of non-renewable and the geographical location of the country, there will be a more generation of electricity through solar cells.

6. CONCLUSION:

The reasonable and effective utilization of solar energy is an important path that can deal with the global energy crisis at present. Photovoltaic (PV) cell, which converts sunlight to electrical current, without any form for mechanical or thermal interlink. So the study on improving the efficiency of solar panels is very necessary. I have proposed several methods (using solar tracker, cleaning dust from the panel, the cooling technique of panel, using anti-reflecting coating, etc.,) to improve the efficiency of solar panels. The practice has proved that the use of these methods can effectively improve the efficiency of solar power generation. Solar tracking mechanisms improve the energy gain of solar power plants. A dual-axis tracking system is generally the one that reaches the highest energy gain in every region. It is, therefore, the most versatile system since it can be installed anywhere, guaranteeing a high energy gain. Solar trackers are recommended everywhere from an energetic point of view since they always increase the amount of collected energy.

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