Increasing the Solar Panel Efficiency after Production by Alternate Methods

N. Lenin Rakesh, R. Srinath, B. Thiagu and R.L. Hari Govindhan

Abstract--- *The objective of this project is to increase the efficiency of the solar panel by using the alternative methods and to utilise the maximum energy from solar energy. Generally the efficiency of the solar panel is about 16%. The solar energy is being wasted in enormous amount without converting it into electricity. There are different ways to increase the efficiency of solar panel. Water or any medium is used to decrease the temperature of the solar panel and maintain at ambient temperature which will help to increase the efficiency of the solar panel. The second method is using mirror in an appropriate angel which will increase the intensity of the solar rays reflect on the solar panel and increases the efficiency. The other method is to use convergence lens which will help to concentrate the solar rays to the solar panel and the efficiency increases. The common method is to have periodic rotation of solar panel according to the sun movement which will increase the time period of production for the solar panel.*

Keywords--- *Solar Energy, Solar Cell, Solar Efficiency, I_{sc}, Area of Collector, Incident Radiant Flux, V_{oc}, MPPT.*

I. INTRODUCTION

A. Photo Voltaic

A photovoltaic (in short PV) module is a packaged, connected assembly of typically 6×10 solar cells. Solar Photovoltaic panels constitute the solar array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions, and typically ranges from 100 to 365 watts. The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. There are a few solar panels available that are exceeding 19% efficiency. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, a solar inverter, and sometimes a battery and interconnection wiring.

Electrical connections are made in series to achieve a desired output voltage and/or in parallel to provide a desired current capability. The conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive transition metals. The cells must be connected electrically to one another and to the rest of the system. Externally, popular terrestrial usage photovoltaic modules use MC3 (older) or MC4 connectors to facilitate easy weatherproof connections to the rest of the system.

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B. Efficiency of PV

The efficiency is the most commonly used parameter to compare the performance of one solar cell to another. Efficiency is defined as the ratio of energy output from the solar cell to input energy from the sun. In addition to reflecting the performance of the solar cell itself, the efficiency depends on the spectrum and intensity of the incident sunlight and the temperature of the solar cell. Therefore, conditions under which efficiency is measured must be carefully controlled in order to compare the performance of one device to another. Most solar panels are around 11-15% efficient.

Fig 1: Solar Cell

The efficiency rating measures what percentage of sunlight hitting a panel gets turned into electricity that you can use. The higher the efficiency, the less surface area you'll need in your solar panels. Although the average percentage may sound a little low, you can easily outfit a typical roof with enough power to cover your energy needs.

The efficiency of a solar cell is determined as the fraction of incident power which is converted to electricity and is defined as:

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

where V_{oc} is the open-circuit voltage;
where I_{sc} is the short-circuit current; and
where FF is the fill factor
where η is the efficiency.

Efficiency is how good the solar panel is at changing the Sun's light to electricity. You can think of it as the percentage of the light that hits the panel that ends up as electricity. So a panel with 50% efficiency would be able to change one-half of the light that hits the panel to electrical energy. Scientists define it as the ratio of how much power the panel generates to how much power the panels receive from the Sun.

II. FACTORS EFFECTING EFFICIENCY OF SOLAR PANEL

A. Panel orientation

The ingredients are mixed thoroughly with rubber to get a uniform dispersion in the materials. The mixing was done in shear mixer with cutters and some samples with vulcanization properties and agents are also mixed with it but before mixing it . the materials are heat treated for about 150ºc.

B. Roof and panel pitch

The "pitch" or tilt of your roof can affect the number of hours of sunlight you receive in an average day throughout the year. Large commercial systems have solar tracking systems that automatically follow the sun's tilt through the day. These are expensive, however, and not typically used for residential solar installs.

C. Temperature

Some panels like it hot but most don't. So, panels typically need to be installed a few inches above the roof with enough air flow to cool them down. Some photovoltaic panels are designed to be more efficient in hotter climates. Hot temperatures can reduce the efficiency of solar panels.

D. Shade

Basically, shade is the enemy of solar panel efficiency. With poor solar design, even a little shade on one panel can shut down energy production on all of your other panels (like a bad bulb in a string of Christmas lights). Before designing a system there is a need of complete study of the shade of the place where panels are need to be placed to reveal its patterns of shade and sunlight throughout the year.

E. Optimal position

In addition to efficiency and size, there are other factors that affect how much power your solar panels will generate. It's important to make sure panels are installed in the optimal position, which is why you want to work with a highly experienced provider. The installers we work with will determine the correct orientation for your panels based on the direction and angle of your roof. They'll also make sure the panels are installed with the proper amount of airflow so they stay cool– solar panels don't like it too hot, and they'll produce more power if they're the right temperature.

Fig 2: Panel orientation

III. METHODS TO INCREASE EFFICIENCY

Using mirror

Most of the time a solar panel is working well below peak power, on hazy days and when the sun is lower in the sky, early morning, late afternoon for example. The light levels are just not high enough, so to boost the light level I tried aligning a mirror to reflect more light onto my solar panel. It worked really well and after a bit of experimentation I found that placing a mirror at least twice the size of the solar panel on the ground in front of the panel could boost the output by as much as 75%. Using a bigger mirror can reflect light onto your panel over a longer period during the day so you don't need to track the sun, just face your panel and mirror due south.

The practice: I bought a solar panel for testing this idea, below are some pictures showing what I did and the meter readings just to show that it really does work. Pictured below is the 1.5w solar panel facing south just placed on a wood board to stop the grass shading the panel. The meter is showing 0.07 amps, that's approximately 0.84 watts, Even on every sunny day the panel is only producing just over half its peak power.

Fig 3: Solar panel in normal condition

In the picture below you can see how the mirror reflects light onto the solar panel. The panel produced 0.12 amps, about 1.44 watts, very close to the maximum rated output for this panel.

Fig 4: Use of Solar panel

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If you use a large mirror there is no need to align it to reflect light onto the solar panel just drop it on the ground in front of the panel for an instant 75% power boost. This is probably one of the cheapest and easiest ways to boost the power of a small solar panel.

The limitations of this method:

You can use more mirrors to reflect more light onto the solar panel and increase its power further but on a sunny summers day the extra light can build up a lot of heat that may damage the panel. In July I had my 1.5w panel running at double its rated power for twenty minutes, it got so hot you couldn't touch it!

- Placing mirrors either side of the panel to reflect doesn't work well because as the sun moves west it will cast a shadow across the panel. The only place that the mirror won't cast a shadow at any time in the day is on the ground in front of the solar panel.
- On a dull day the mirror doesn't give much of a power boost at all, I tested a panel on a dull day in October; it produced 1% of its rated power, adding a mirror made no difference.
- If you're concerned about having sheets of glass lying on the ground you could use polished metal instead, I found it nearly as good as mirror glass.
- This method probably won't work if you have solar panels mounted on your roof, for obvious reasons.

Cooling Solar panel

The increase in temperature from 25ºC increases the generation of electron- hole pair in the photovoltaic module which thus leads to increase in the mobility within the p-n junction leading to increase in current of the module. Figure 1 shows that the current increases with temperature to about 43ºC where surge in current is observed and beyond this temperature, current begins to drop, thus indicating the maximum operating temperature of the photovoltaic module.

One of the main obstacles that face the operation of photovoltaic panels (PV) is overheating due to excessive solar radiation and high ambient temperatures. Overheating reduces the efficiency of the panels dramatically. The ideal P–V characteristics of a solar cell for a temperature variation between 0^o C and 75^o C are shown in the figure, which is adopted from Rodrigues t al. The P–V characteristic is the relation between the electrical power output P of the solar cell and the output voltage, V, while the solar irradiance, E, and module temperature, Tm, are kept constant. If any of those two factors, namely Tm and E, are changed the whole characteristics change. The maximum power output from the solar cells decreases as the cell temperature increases, as can be seen in the figure. The temperature coefficient of the PV panels is $0.5\%/^o$ C, which indicates that every 1^o C of temperature rise corresponds to a drop in the efficiency by 0.5%. This indicates that heating of the PV panels can affect the output of the panels significantly. Hybrid Photovoltaic/Thermal (PV/T) solar system is one of the most popular methods for cooling the photovoltaic panels nowadays. The hybrid system consists of a solar photovoltaic panels combined with a cooling system. The cooling agent, i.e., water or air, is circulated around the PV panels for cooling the solar cells, such that the warm water or air leaving the panels may be used for domestic applications such as domestic heating. In a hybrid PV/T solar system found that cooling the solar photovoltaic panel with water increases the solar cells output power by almost 50%.

They also found that cooling the solar photovoltaic panel does not allow the solar cells surface temperature to rise above 46^{o} C when exposed to solar radiation for a period of 4 h. In a hybrid PV/T solar system where water and air were both investigated in the combined system as cooling agents. The water-based cooling system was found to increase the solar cells performance higher than the air based cooling system.

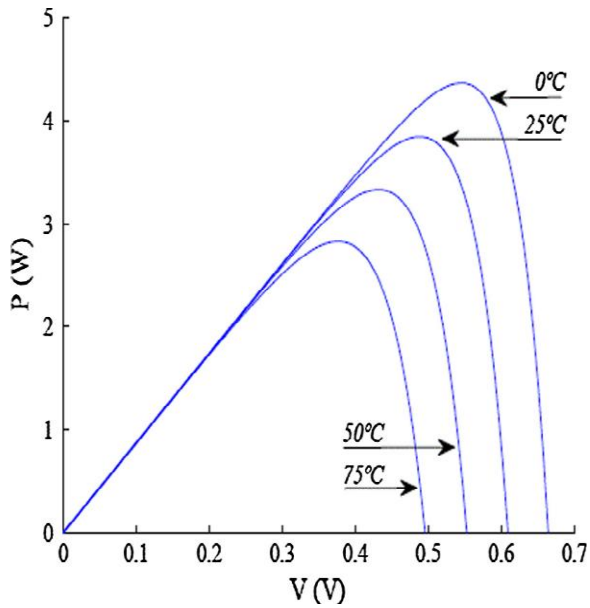

Fig 5: P–V characteristics as a function of the module temperature Tm, adopted from the module temperature varies between 0o C and 75oC.

It can be concluded that using water as a coolant is found to be more effective than using air. A non-pressurized cooling system has been developed based on spraying the PV panels by water once in a while. A cooling rate model has been developed to determine how long it will take to cool the PV panels by water spraying to its operating temperature. A mathematical model has been used to determine the heating rate of the PV panels, in order to determine when to start cooling. To study the influence of cooling on the performance of PV panels it can be concluded from the results of this study that the cooling rate for the solar cells is 2^{o} C/min based on the concerned operating conditions, which means that the cooling system will be operated each time for 5 min, in order to decrease the module temperature by 10^{o} C. The result of the cooling rate model has shown good agreement with the experimental measurements. The PV panels yields the highest output energy if cooling of the panels starts when the temperature of the PV panels reaches the maximum allowable temperature (MAT), i.e., 45^{o} C. The MAT is a compromise temperature between the output energy from the PV panels and the energy needed for cooling. By the help of water the solar panel is maintained with ambient temperature and thus the efficiency increases by 50%. The cooling is done to minimise the temperature of the solar cell and the efficiency of the cell varies for each degree of the solar cell. In a solar cell, the parameter most affected by an increase in temperature is the open-circuit voltage. The impact of increasing temperature is shown in the figure below

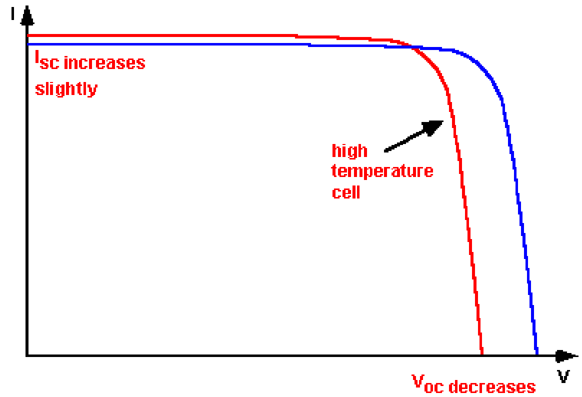

Fig.6: The effect of temperature on the I-V characteristics of a solar cell.

Temperature can affect how electricity flows through an electrical circuit by changing the speed at which the electrons travel. Also, since solar panels work best at certain weather and temperature conditions, engineers design ways to improve the efficiency of solar panels that operate in non-optimal temperature conditions. This might involve designing cooling systems that use outside air, fans and pumps.

IV. COMPLETE RESULT

From the above results we infer that.

- The solar panel must be used up to the most.
- The efficiency of the solar panel need to be increased by some methods.
- The efficiency can be increased by using mirror in front of the solar panel.
- The efficiency can also be increased by cooling the solar panel.
- Both methods are eco friendly and harmless.

Thus we infer that **the efficiency of the solar panel be increased by using alternate and eco friendly methods.**

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