ANALYSIS OF EFFICIENCY LOSSES IN SOLAR CELL

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Abstract: **Solar energy is a "green source of energy" can be harnessed from the power and heat of the sun's rays. Solar energy is being recognized as the future of alternative energy sources as it is non-polluting that helps to combat the Greenhouse effect on global climate created by use of fossils fuels. Solar power is anticipated to become the world's largest source of electricity by 2050. It is being researched and concluded that solar photovoltaic's and concentrated solar power contributing 16 and 11 percent to the global overall consumption, respectively. In 2016, after another year of rapid growth, solar generated 1.3% of global power. The future scope and research lies in harnessing the solar energy through the solar panels; that could be organic or photovoltaic cell. But the efficiency of the system of harnessing the energy matters in the whole scenario, i.e. how could the efficiency be optimized by regulating the factors affecting the losses and hence emphasizing over the remedies of these losses. Hence, this paper introduces the facts on how the losses affect the efficiency and concludes the remedies to improve the efficiency of the panel system.**

KEYWORDS– efficiency, solar cell, monocrystalline solar cells, Polycrystalline solar cell, losses facto, solutions

I.INTROIDUCTION

Solar energy is a renewable resource energy obtained from the sun unlike the fossil fuels and is environmentally friendly. Solar energy is available just about everywhere on earth and could be harnessed whole day and with the technology help, can be used on the cloudy day as well. This source of energy is free, immune to rising energy prices. Solar energy can be used in many ways – to provide heat, lighting, mechanical power and electricity. It is how solar energy is converted into electricity by using either photo-voltaic (direct method) or concentrated solar power (Indirect). Large beams of sunlight are focused into a small beam using mirrors or lenses in the case of concentrated solar power. Photoelectric effect is used by Photo voltaic to convert solar energy into electric energy.

WHAT IS A SOLAR CELL –

A structure that converts solar energy directly to the DC electric energy

- It supplies a voltage and a current to a resistive load(light, battery, motor)
- Power = Current x Voltage
- It is like a battery because it supplies DC power
- It is not like battery because the voltage supplied by the cell changes with changes in the resistance of the load.

CHARACTERISTICS –

- Consumes no fuel
- No pollution
- Wide power handling capabilities
- High power to weight ratio

Solar panels use doesn't actually replace the traditional electricity use but they simply supplement them with power from a greener source when possible. Conversely, if you generate too much solar power you can sell the energy back to the National Grid at an agreed rate through the Feed-in Tariff scheme.

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic's (PV), or indirectly using concentrated solar power (CSP). CSP systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. PV converts light into electric current using the photoelectric effect.

II.TYPES OF SOLAR CELLS:

(i) Monocrystalline silicon PV panels These are made using cells sliced from a single cylindrical crystal of silicon. This is the most efficient photovoltaic technology, typically converting around 15% of the sun's energy into electricity.

(ii) Polycrystalline silicon PV panel Also sometimes known as multicrystalline cells, polycrystalline silicon cells are made from cells cut from an ingot of melted and recrystallized silicon. They tend to be slightly less efficient, with average efficiencies of around 12%.

(iii)Thick-film silicon PV panels This is a variant on multicrystalline technology where the silicon is deposited in a continuous process onto a base material giving a fine grained, sparkling appearance.

(iv) Amorphous silicon PV panels Amorphous silicon cells are made by depositing silicon in a thin homogenous layer onto a substrate rather than creating a rigid crystal structure This technology is, however, less efficient than crystalline silicon, with typical efficiencies of around 6%, but it tends to be easier and cheaper to produce. If roof space is not restricted, an amorphous product can be a good option.

III. SOLAR PANEL CHARGING SYSTEM

.PV generators are neither constant voltage sources nor current sources but can be approximated as current generators with dependant voltage sources. During darkness, the solar cell is not an active device because of no sunlight; it produces neither a current nor a voltage. However, if it is connected to an external supply (large voltage) it generates a current I_d, called diode current or dark current. The diode determines the V-I characteristics of the cell. There are three different models of PV cells generally available which are already mentioned above. The circuit diagram shown below is a panel charging system. The output voltage is the resultant voltage of the system

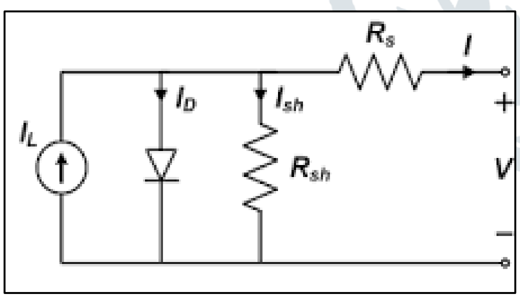

Figure1: Panel charging system

IV.SOLAR CELL EFFICIENCY

The solar cell efficiency is the most important parameter determining how efficient the solar cell is when compared with another. Efficiency is defined as the ratio of energy output from the solar cell to the input energy which is solar energy.

SOLAR CELL EFFICIENCY =

$$\frac{\textbf{POWER OUT (w) X 100\%}}{\textbf{AREA (m\^{}2) x 1000W/m\^{}2}}$$

How long do solar panels last?

Solar panels are manhandles for a long. They do not include any motherboard, processor, pumps, fans etc, in short the delicate moving parts. Components of solar cell are durable and its job is to sit in one place and absorbs all the energy it can from the sun. With the improvement in solar technology, the performance of solar panel has only got better over the time. Most of the modern solar panels are efficient as well.

Annually, the efficiency of solar panels just decreases by half a percent. The losses in mainly due to water vapor exposure and temperature fluctuations, weather conditions over the region, etc. the image shows how log the efficiency of solar panels lat over the time.

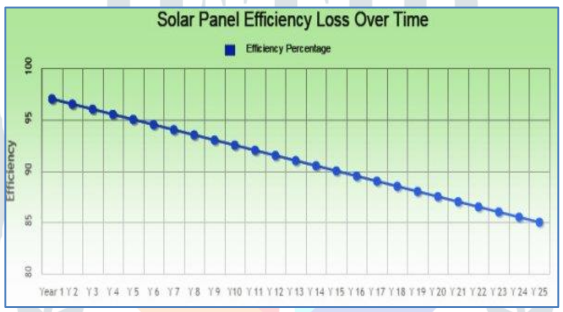

Figure 2: Solar panel efficiency loss over time

V.SOLAR CELL LOSSES

Diode and connection loss: The application of bypass diodes is photovoltaic system. Photovoltaic system is to protect photovoltaic modules in partial shading conditions. Such a protective component can cause major problem i.e. power loss which we commonly say power loss in the system. The other know connection loss in photovoltaic system happens in photovoltaic modules and other electrical components are connect together to form photovoltaic array, that is very popularly known as resistive loss.

Sun tracking losses: Sun moves across the sky during the day time. In the situation when it is fixed solar collectors, the estimation of the collector area on the plane, which is perpendicular to the radiation direction, given by function cosine of the angle of incident. Sun tracking loss happens whenever the single or dual axes of tracking solar panel are not set in the condition of optimum orientation, or are misaligned because of mechanical failure.

Mismatch losses: when photovoltaic modules with different characteristics(I&V) are connected together they gives a total power less than the power attained by summing the output power provided by each of the modules. And current and voltage characteristics are not identical for same photovoltaic module. This inequality causes photovoltaic module to compress on common voltage and module. And when they connected in series or parallel then power loss occur that is known as mismatch loss.

Inverters: The main components to a solar panel's installation, the inverter convert electricity produced by the solar panel from direct current to alternating current. Nowadays there are two inverter schemes that one panel can use it. The first is single, central inverter. The other is a multi-scheme setup that utilizes 2 or more inverters in an array. In this setup, each of the panels has its own different inverter. The lifeline of any inverter is near about a decade and with a standard deviation inverter have lifeline of 3 years. And the inverter life spans have a very huge problem.

Monitoring failure: Nowadays inverters are usually having monitoring instrument integrated into their build. And current and voltage output can be measured. And for new models of inverters, if the data link is broken, it would help check the inverter itself to see if the data link is turned on and information is being monitored. And for older models though, one must check each individual instrument to make sure the data stream is up or not.

Panel orientation and grid: This is an issue that must be checked before a system is installed. It requires due representative on the consumer's part to make sure the installer is taking the proper steps necessary to determine an ideal panel orientation. For static panels, though, it is essential to have an ideal panel orientation. Depending on your location, there is a unique tilt angle and solar azimuth angle to optimize energy output.

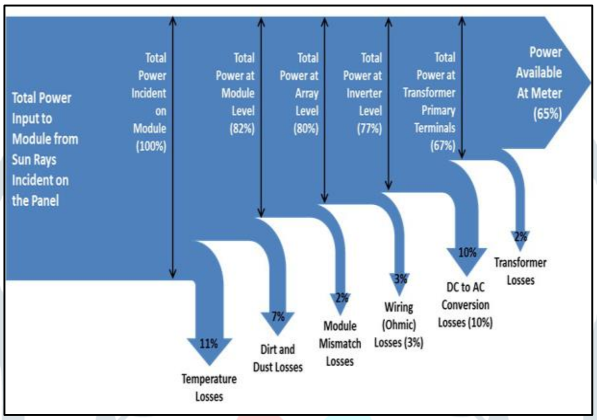

Figure 3: Snaky diagram on Solar PV system overall losses

VI. LOSSES AFFECTING PHYSICAL PROPERTIES:

Shading loss: This happens when photovoltaic modules are shaded by some tress, buildings or other body closes to photovoltaic modules. And this shading affect the performance of photovoltaic module. The photovoltaic system is having problem and biggest weakness of nonlinearity between current and voltage under half shading condition. And according to statistic research the power loss can vary from 10% to 70% due to PS.

Soiling losses: This loss refers to loss in power from snow, dirt, dust, and so many other particles that cover the surface of photovoltaic module. Dust is a very thin layer that covers the outer surface of solar array. And the typical dust particles are less than 10µm in diameter but this depends on the location and its environment. Dust is generated from many sources such as pollution by wind, pedestrian volcanic eruptions, and vehicular movements among many others. The accumulated dust over time aggravates the soiling effect. In fact, the amount of accumulated dust on the surface of the PV module affects the overall energy delivered from the PV module on a daily, monthly, seasonal and annual basis.

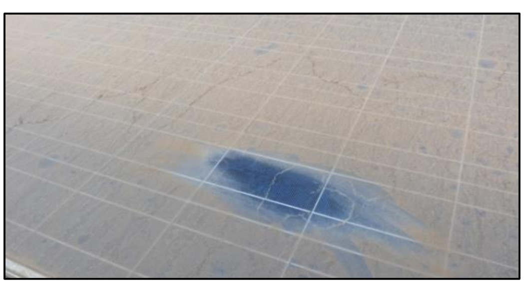

Figure 4: Dust particles on the solar panel system

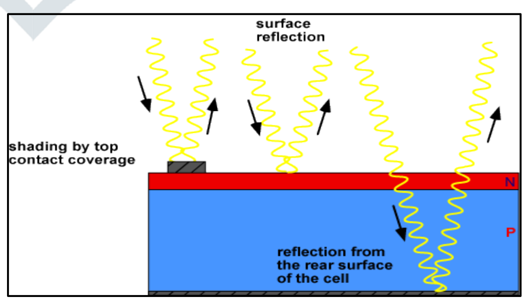

Figure 5: Soiling losses phenomenon

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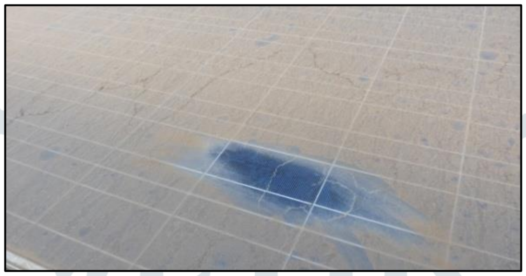

Figure 6: Dust particles on the solar panel system

Panel cracking: This is caused by different types of sources. Physical impact, oscillation from wind or manufacturing defects can lead to crack the panel. Cracks will reduce module energy output and efficiency. This is because the cracking will alter the optical properties of the panel, and cause light to penetrate the surface of the panel differently. This leads to loss of efficiency because the maximum amount of light is not penetrating the panel.

Figure 7: Cracked Panel

WIND: Just like soiling losses wind is a positional problem. Because of regulations, all of solar panels must be tested to hold some definite wind loads. However, the wind loads are notable but they do not exactly imitate wind patterns in real life. Because in testing, a panel will be put in a wind tunnel and blasted with wind linearly from a single direction for testing. In the field, wind patterns are not linear, and can cause damage to solar panels. This happen when oscillation is induced, and a large enough frequency of vibration is reached that it will cause the panels to completely break. As discussed by Banks, many wind patterns are whirlwinds, and cause lift under solar panels. The most vulnerable part of an array is the corners, and often depending on the orientation of the surroundings, and the position on the panels, this can be a deciding factor whether or not if your array will survive through the wind over a 20-25-year lifespan. Currently there is no easily accessible way of testing if solar panels can handle dynamic wind loads. It would require accurate fluid dynamics simulations to see if panels are sturdy enough. Usually installers are very knowledgeable about wind loads, and through years of experience will be able to tell if it will be an issue. As all installers require an inspection before any building takes place, a professional Photovoltaic installer will be able to foresee any large issues.

FIGURE8: Panel losses due to wind

VII.COMPLEMENTARY SOLUTIONS OF THE DIFFERENT LOSSES:

Solar panels in the dusty regions could be cleaned by detergents and water. But cleaning dusty dirty panels with ordinary commercial detergents can be time-consuming, costly, very harmful to the environment, or even corrode the surface of the panel frame. Normally solar panels should be cleaned every few weeks to maintain its high efficiency, which is especially hard to do for large solar-panel arrays setup. Even this cleaning costs up to five dollars per panel.

Other solutions for the solar panel cleaning could be retained by robust coating.

Robust coating: To prevent solar panel with this problem, Seamus Curran, associate professor of physics at the University of Houston and director of the Institute for Nano Energy, which specializes in the design, engineering, and assembly of nanostructures has developed a self-cleaning Nano hydrophobic material that time that coats the solar panel to maintain its highest efficiency over longer time period Curran's Nano hydrophobic coating can applied to a variety of surface materials, including glass, cloth fibers, wood, textiles, and plastic. The layer is so thin that it does not scatter light, and therefore, does not interfere with the solar panel's performance.

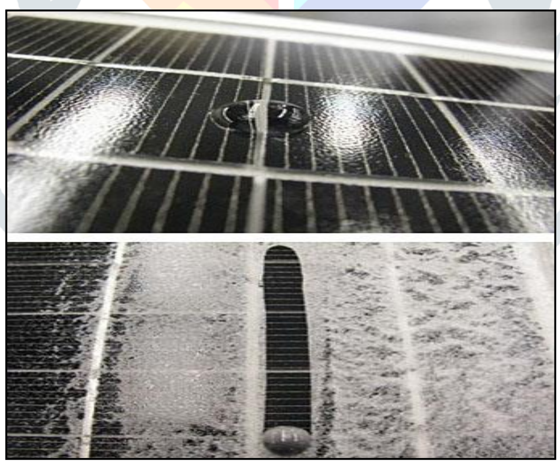

Figure 9: Self-Cleaning Hydrophobic Coatings (SCHN107™) Layer, licensed by C-Voltaics, prevents dust buildup, water stain and weathering. *Image source: C-voltaics.com*

Water is the main reasons solar panels get dirty. Rain and condensation settle in the micro depressions present in the glass surface, where they attract particulate matter. The water easily and quickly evaporates, leaving a dirty residue behind that is difficult to remove. However, an application of the Nano hydrophobic layer fills in the micro depressions, creating a smooth glass surface that cannot hold water. Heat or temperature losses are one of the major factors affecting the efficiency. Temperature can significantly reduce the output of a PV system. This efficiency loss could be avoided by the following media:

Determining the efficiency of the panel according to the seasonal variation and geographical region for example, high concentration PV, which is designed for hot climate, should be priory considered.

Reducing the effects of the heat:

- By Installing panels a few inches above the rooftop to allow convective air flow to cool the panels down.
- By ensuring that panels are constructed with light-colored materials, to reduce heat absorption.
- By moving the components like inverters and combiners into the shaded area behind the array.
-

VIII.ANALYTICAL ANALYSIS:

There are uncountable reasons that are responsible for the contamination of dirt that could not be removed through self cleaning process. Though cleaning process is required, but the cost and time are the two factors is prominently needed. When we decide to clean the PV module system, its yield improvement can also be assessed. Here is an example shows the impact of cleaning to the PV system yield performance.

The performance of a 100 KWP PV system before and after cleaning is compared on the given graph below. A reference PV system is also taken into account which has less pollution load. Both photovoltaic systems were running systematically without any failure. The predicted measurements are also compared in the period.

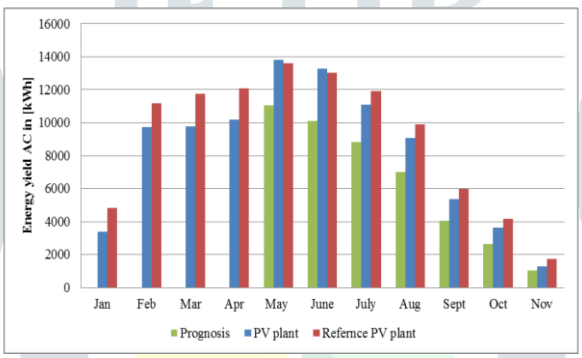

FIGURE 10: shows the monthly yield of the PV plant in blue, the predicted measurement in green and the reference PV plant in red. The PV plant was cleaned in the month of May. After cleaning a yield increase measured more than 15% was measured and only two months after the cleaning the monthly yield dropped again and continuously degraded over times. (PC: smartblue.com)

X. CONLUSION:

Solar energy is conceivably a limitless resource. It is prominently used for harnessing energy and its capabilities even known to every human. Since, from many decades it has become the topic of research and development and hence, also the improving factor of its losses which aid restrictions to its efficiency. The sun provides the enough energy in a minute to fulfill the energy needs of the world for a year. But using this resource efficiently and to introduce it to supple demand is quiet difficult. And counter to this the silicon based solar cells also suffer from decline in their effectiveness over the time. The different types of losses affecting the panel have been described. But the need of hour is to lay emphasis on its effectiveness by researching more over on the solutions.

Some ideal solutions have been mentioned like robust coating and self cleaning and also the other governing facts which help to retain the losses. The effects of shading losses can the solutions too, by installing the micro inverters with every panel string to avoid these problems. Dust cleaning can be done by rainfall, which is free of charge but seasonally available. Manual cleaning can be done which is the same process like that of cleaning glass windows of the building. Mobile cleaning utilizes machinery task for sprinkling water and storage of water supply (harvesting water resources is also need to be done).

This paper though providing the concerning facts over the issue of solar panel losses affecting its efficiency also gives a general idea of the topic of research on the cleaning methods. There is much need to emphasize our concern over the research which should derive the cleaning solutions as well as which also increase the efficiency through some innovative result.

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