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A Review of Photovoltaic Cell and its Future Trends

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Abstract - ***Today energy is the main inspiration for nation economic development. Sun is large source of free energy, so we are getting large amount of free energy from the Sun. Out of which only a small energy is used. The light come from the sun is a non-destroyable source of energy which is free from environmental pollution and noise.***

Solar Photovoltaic technology used for conversion of sunlight energy into electrical energy. Solar cells mostly manufactured from Silicon material. Such silicon material is a base of solar cells. The first generation solar cells grown on Silicon wafers, mainly single crystals. Afterward to develop a thin films dye sensitized solar cells. Also organic solar cells was developed for enhance the cell efficiency. Such development is basically depending on the cost and efficiency.

The aim of this paper is to discuss the different types of photovoltaic cells and focus on the current research directions on their development and manufacturing technologies.

***Key Words*:**
Solar cells, Renewable energy, Photovoltaic cell manufacturing Technologies, Efficiency, Photovoltaic generations.

1. INTRODUCTION

Renewable energy is rapidly increasing importance because of fossil fuel prices up and down. One of the most likely renewable energy sources is solar power [1]. Sun emitted out huge amount of energy in the form of heat and radiations called as a solar energy. Energy of Sun is an infinite source of energy which is available at free of cost. As compare to other power source major benefit of solar energy is that the sunlight can be directly converted into Electric energy with the help of photovoltaic (PV) solar cells [2].

Sun is a large gaseous sphere, which is giving a huge amount of energy due to fusion of hydrogen nuclei, in the form of radiations. Sun is release approximately 6.4*107 W/m2. Out of which ~ 1370 W/m2 is occurrence on the Earth's atmosphere considering no absorption of sunlight in space and about 980 W/m2 power density reaches Earth's surface. Solar energy can be easily converted into electricity by using solar cells. There are few limitations to use of solar energy. First it's not available at night and second it's not constant every time. The sunlight found on the Earth's surface go through different layers of atmosphere containg various particles and varies largely due to atmospheric effect including absorption of sunlight and scattering, difference in the local atmosphere like vapors, dust, smoke, pollution fog and also season & time of the day.

Air mass (AM) is the length which sunlight transmitted through atmosphere normalized to shortest path lengths when Sun is straight or overhead.

Air mass (AM),

$$AM = 1 \div Cos\ \theta$$

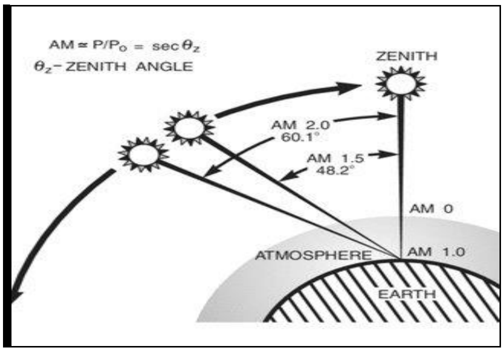


Figure 01- Dependency between coefficient AM (Air Mass) and the zenith angle

Where, θ is the angle from vertical or zenith angle see in figure 1.

Standard value of AM is considered as a 1.5 [3]. The improvement of solar cell efficiency depends on reducing various types of losses [4]. In general, there are three methods to increase the efficiency of PV systems. The first method is to increase the generation efficiency of solar cells; the second one is related to the energy conversion system included maximum power point tracking control and the third is related to solar tracking system to obtain more solar energy input from the sun [1].

In the old days, different types of semiconductor materials and technologies are found to design solar cells with minimum cost and high conversion rate of efficiency. Past solar panels made from silicon crystalline wafer modules are heavy weight which makes the transportation difficulties. These are generally related to the large solar panels covered with glass sheets. A large solar panel requires a lot of space and sometime big roofs for fittings. Therefore, in this article keeping in mind, we will study the different types of solar cells [2].

2. PHOTOVOLTAICS WORK

The photoelectric effect was first found by a French physicist, Edmund Becquerel, in 1839, who noted that certain materials would produce small amounts of electric current when exposed to light.

Afterward in 1954 the first proper developed photovoltaic module was built by Bell Laboratories. It was developed as a solar battery and was mostly just a curiosity as it was too expensive. In the 1960s, the space industry began to research on the solar technology to provide power for spacecraft. Through the space programs, the technology advanced, its reliability was established, and the cost starts to decline. In the 1970s, photovoltaic technology raised as a source of power for non-space applications.

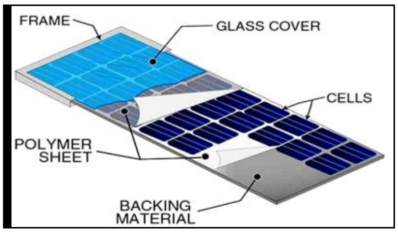


Figure 02- Solar Panels Making

When light energy emitted on the solar cell, electrons are loose from the atoms in the semiconductor material. If electrical conductors are connected to the positive and negative terminals, creating an electrical circuit, the electrons can be reproduce in the form of an electric current this is called as electricity. This electricity afterward used to power a load, such as a light or a tool.

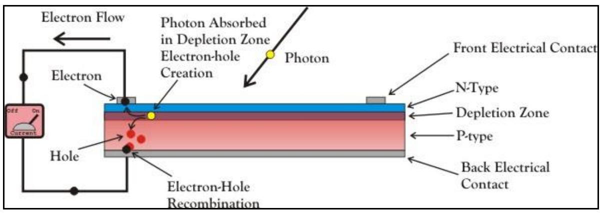


Figure 03- Photovoltaic working

2.1 HOW TO CALCULATE SOLAR PANEL EFFICIENCY:

To calculate the maximum efficiency of the solar panel we need to divide the ratio of panel power to sun power by the area of the panel in square meters, then times by 100 to get a percentage.

To determine the efficiency of the panel, we need to compare the power that the sun provides to the panel to the electricity that is produced. If a panel was able to convert all of the light that falls on it into electricity, then that panel would be 100% efficient. Unfortunately, this level of efficiency is impossible.

The equation below can be used to calculate the approximate efficiency of a solar panel, as a percentage:

$$efficiency = \frac{panel\ power\ (in\ kW)}{panel\ length \times panel\ width\ (in\ m)} \times 100\%$$

It is important to stress that efficiency of a solar panel is a matter of area, not power. A 10% efficient 100W panel and a 20% efficient 100W panel will both produce exactly the same amount of power. However, you should expect the 20% efficient solar panel to be half the total size of the 10% efficient panel.

To begin comparing the sun's power to the panel's electricity output, we first need to know the sun's power. At midday near the equator, just over 1kW (1000W) of sunlight reaches every square meter of the ground. Away from the equator and in different seasons, weather conditions and times of day this will be less, but the 1kW per square meter value is used when testing panels to give the power rating they are sold as. This part of the standard test conditions (STC) that the solar power industry uses, and all panels are rated in the same way.

Imagine a panel with an area of 1 square meter. If it produced 1kW of electricity at noon on the equator we could say that it was 100% efficient as it would receive 1kW of sunlight and turn that into the same amount of electricity. If a panel the same size instead produced 200W of power, then its efficiency is 200W/1000W x 100 = 20%. If we instead express this in kW then the equation becomes even simpler, as 0.2kW/1kW = 0.2 so the sun's power can be ignored in the calculation. The ratio is multiplied by 100 to give an answer in percentage.

To perform this calculation for any solar panel that isn't 1 square meter, we need to know the area of the panel. If a panel is half as big and produces the same power it is twice as efficient, and vice versa. The area can be easily calculated from the panel's dimensions by multiplying the width by the length. Remember to convert the dimensions into meters first as areas do not convert in the same way as lengths (i.e. 1 square meter is not 1000 square millimeters, it is 1 million square millimeters).

Finally, to calculate the maximum efficiency of the solar panel we need to divide the ratio of panel power to sun power by the area of the panel in square meters, then times by 100 to get a percentage. Make sure the measurement units of all the values are correct or you will end up with very strange results.

Take, for example, our 300W rigid frame panel with monocrystalline silicon cells. Its power is 300W or 0.3kW; it is 1.64m long and 0.99m wide. The efficiency is therefore:

$$\frac{0.3kW}{1.64m \times 0.99m} \times 100\% = 18.1\%$$

This is the approximate efficiency of the panel as a whole, so as mentioned above we would expect it to be lower than the efficiency of the cells because of the frame and gaps between the solar cells (increasing the area) and normal losses as the electricity travels through the panel and wires. For a higher efficiency panel of the same area, the power would be higher than 300W.

2.2 DIFFERENT TYPES OF SOLAR CELL

In the olden days, photovoltaic cell has become a major contributor to the ongoing energy move. Challenges relating to PV materials and producing methods have a remarkable role behind that development. However, there are still some challenges before photovoltaic can provide clean and low-cost energy. Researchers in this direction focused on to make cheap photovoltaic devices such as multi-junction cells, grapheme or intermediate band gap cells, and printable solar cell materials such as quantum dots cell [4].

Due to the development of many non-conventional manufacturing methods for fabricating solar cells, PV technologies can be divided into four major generations, which is shown in Figure 4.

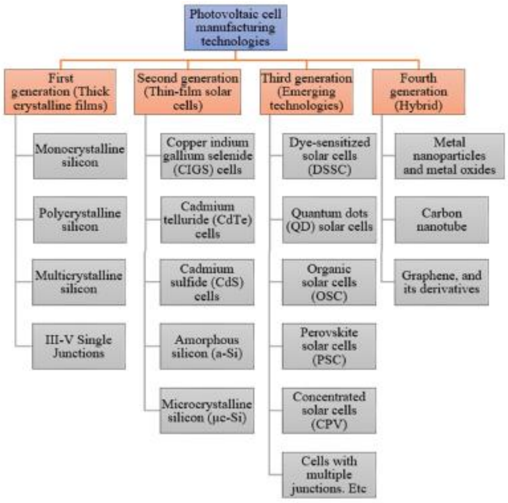


Figure 04- Various solar cell types

The different generations of PV cells tell the story of the stages of their previous development. There are four main types that are described as the generations of PV technology for the last few years, from the development of solar cells [4]:

1. First Generation: This includes photovoltaic (PV) cell technologies based on monocrystalline and polycrystalline silicon and gallium arsenide.

2. Second Generation: This includes the development of thin film photovoltaic cell technology from microcrystalline silicon and amorphous silicon, copper indium gallium selenide and cadmium telluride/cadmium sulfide materials photovoltaic cells.

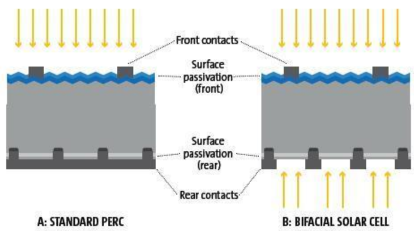
3. Third Generation: This photovoltaic technology is based on more recent chemical compositions. In addition, these technologies using nano-crystalline films, quantum dots, dye-sensitized solar cells. Also a solar cell based on organic polymers is belongs to this generation.

4. Fourth Generation: This technology includes the low cost of thin film polymers along with the durability of innovative inorganic organic-based nanomaterial's such as metal oxides and metal nanoparticles or grapheme, carbon nanotubes.

3. FUTURE OF SOLAR CELL

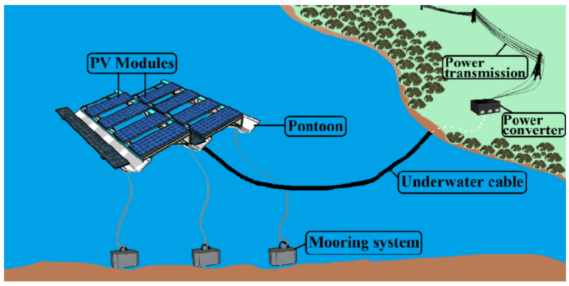
Solar cell technology is a very vast field in which, we can tackle a huge amount of solar power exploit on Earth's surface. Large solar panels are required to capture this emitted sunlight. This energy can be stored and used in different applications is possible. Put together large solar panels and maintaining these solar panels could become difficult and hectic. As well as large land is wasted for constructing these solar panels. In Asian countries land available per square feet for an individual is very less and erection of large Solar panels would cause crisis of land. So more advanced and smart solar panels can be designed to overcome this problem.

a) Bifacial Solar cells: One of the advanced kinds of solar cell technology, Passivated Emitter Rear Cell (PERC) could give more efficiency.



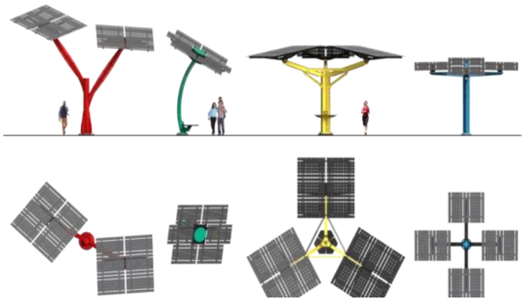
Bifacial solar cells are used for of generating electricity not only from the sunlight incident on the front surface of a solar cell as well as from reflected sunlight at the rear part.

b) Floating PV technology: In order to obtain solution for wastage of large water landscape, large water bodies can be used to erect PV cells.



c) Integrated PV panels: PV panels integrated in building architecture would be providing solution to difficulties like bulky solar panel arrays their installation and maintenance.

d) Solar Trees: Take an idea from natural trees; we develop the solar trees which would be capable of converting almost whole amount of incident sunlight and producing electricity.



e) Agro-photovoltaic: Similarly agriculture land can be used for growing crops as well as for solar panel installation.

4. FUTURE OF SOLAR-POWER

The next few years of solar energy are likely to look very different than the past years. Photovoltaic (PV) and concentrating solar power are take a grip rapidly in upcoming years. The National Renewable Energy Laboratory (NREL) projects solar energy could provide 45% of the electricity in the United States by 2050 if the energy system is fully decarbonized.

So, in future based on current government policies & trends we focus three visions of the solar power,

1. The Untapped Solar Potential of Buildings:

Solar energy will combine with the buildings we live, work, and play in through two main ways: how solar systems are expand on these buildings, and how these buildings can vary their use and storage of solar power. Both subjects are major, largely untapped avenues of supporting decarburization across the power grid. Today, only about 4 % of solar-viable rooftops in the India actually use PV systems.

2. Affordable and Accessible Solar Energy:

Solar energy expansion promises economic and flexible benefits for many communities, but without attention to how and why communities and individuals adopt solar energy, these benefits are unlikely to be shared uniformly. Overcoming past variations in solar access has obvious benefits to local air quality, climate change mitigation, and community opportunities.

3. Vehicle-Solar Synergy:

Electric transportation is another way in the future of solar energy. The *study* finds that solar energy could power about 14% of transportation end uses by 2050. Solar PV couples well to electric vehicle (EV) charging: Both use direct-current electricity, which avoids efficiency losses in conversion to alternating-current electricity a much as 26% lost, in some cases. Using EV batteries for second-life storage applications, and even equipping solar PV panels directly on vehicles.

4. CONCLUSION

Today world face the climate changing has become a major concerned issue. Due to this issue, environmental hazards like crisis of energy sources, volatile oil prices, security and safety of energy sources has laid the way of transforming energy sector of the globe. With the help of clean energy i. e. solar energy we make a de-carbonization conventional energy system of world. Ever increasing energy demand of world's growing population could be satisfied by using one or more energy technology along with solar energy.

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