

Sustainable Renewable Solar - Energy by Solar Panels and Photovoltaic System

Anil R.Saradva

Assistant Professor, The H.N.S.B.Ltd.Science College, Himatnagar, Gujarat, India

ABSTRACT

The most sustainable renewable energy is solar energy today. It has been used for thousands of years before the invention of solar panels. The energy of the sun to produce electricity that is renewable and sustainable. Using solar panels, solar energy is converted into electrical energy. Solar energy conversion into electricity with particular emphasis on photovoltaic systems, solar cells and how to store electricity. Index Terms—Solar spectrum, solar cells, positioning, storage. Solar photovoltaics (PV) are the most widely deployed solar electric technology in the world today. Current PV technologies and identifies key strengths and remaining technical challenges associated with each. A large-scale PV deployment in any application area: higher power conversion efficiencies, lower materials usage, and reduced manufacturing complexity and cost.

Keywords : Solar Cell, Solar Panels, Photovoltaic

I. INTRODUCTION

Solar energy is radiant light and heat from the Sun. Today solar energy is used in a couple different manners. Such as solar heating, photovoltaics, solar thermal energy. The photovoltaic conversion format, which most people know as solar panels. These panels are used to create electricity directly from the sun. These panels can be used alone or can be used in conjunction with other power resources. The second type of solar power that is used today is thermal solar power, which is where the sun is used to heat fluids, which then powers turbines or other types of machinery.

It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power.[1] Active solar techniques include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy.

Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air. In 2011, the International Energy Agency said that "the development of affordable, clean solar energy technologies will have huge longer-term benefits. It will increase countries' energy security through reliance on an indigenous, and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating global warming, and keep fossil fuel prices lower than otherwise. These advantages are global. Hence the additional costs of the incentives for early deployment should be considered learning investments;[4] they must be wisely spent and need to be widely shared".[2,3]

1.1 The Science behind Solar Panels:

Solar panels absorb the sunlight as a source of energy to generate electricity or heat. The sun beams more

than enough energy onto the earth to meet the needs of global energy demand for a whole year. Solar panels produce energy less than a tenth of one percent of the entire global energy demand. The panels are called photovoltaic cells which are found on things like spacecraft, rooftops, and calculators. The cells are made of semiconductor materials. When sunlight hits the cells, it knocks the electrons loose from their atoms. The electrons generate electricity as they flow through the cell. A solar panel can generate power with a four-piece battery system that can be filled with unfiltered water, and the battery can recycle water to generate battery or power. If three panels are put together, these can produce enough electrical energy to power a typical solar panel produces 200 watts of power or more. To power a building like a bank, for example, a five kilowatt-hour array, which is about 25 solar panels, is necessary. The solar panels will absorb 1,000 watts of sunlight per square meter on the panels' surfaces. To power a high school building, a 6.25 megawatt capacity, equivalent to 24 solar panels, is needed.[6]

1.2 Advantages of Solar Power:

Solar energy is a clean and renewable energy source. solar panels produce electrical power is ecosystem friendly; Once a solar panel is installed, solar energy can be produced free of charge. Solar energy will last forever whereas it is estimated that the world's oil reserves will last for 30 to 40 years.[10] Solar energy causes no pollution. they do not emit greenhouse gases utilizing solar power can save people from fossil fuel dependence. Fossil fuels are not only nonrenewable but are also the main source of carbon dioxide emissions Solar cells make absolutely no noise at all. Very little maintenance is needed to keep solar cells running. There are no moving parts in a solar cell which makes it impossible to really damage them. In the long term, there can be a high return on investment due to the amount of free energy a solar panel can produce, it is estimated that the average household will see 50% of their energy coming in from solar panels.

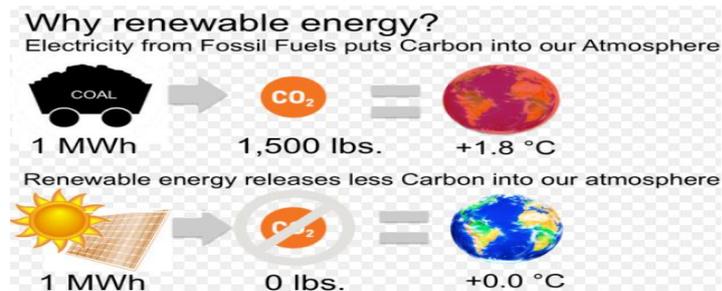


Figure 1

1.3 Disadvantages of Solar Power:

Solar power disadvantages are actually not so plentiful. In fact, there's only one notable disadvantage to solar power that the sun doesn't shine 24 hours a day. When the sun goes down or is heavily shaded, solar PV panels stop producing electricity. If we need electricity at that time, we have to get it from some other source. In other words, we couldn't be 100% powered by solar panels. At the very least, we need batteries to store electricity produced by solar panels for use sometime later. Solar power stations do not match the power output of similar sized conventional power stations; they can also be very expensive to build. Solar power is used to charge batteries so that solar powered devices can be used at night. The batteries can often be large and heavy, taking up space and needing to be replaced from time to time.

1.4 Types of Solar Panel Mountings

There are three types of solar panel mountings. like as fixed, adjustable, and tracking. The fixed solar panel mounting system is completely stationary. This is the simplest and cheapest type of solar panel.(Figure 2) The solar panels are installed in such a way that they are always facing the equator (due south in the northern hemisphere).



Figure 2. Fixed Solar Panel Mount

The adjustable solar panel mounting system includes adjusting the angle of inclination of the solar panel mount two or more times a year to account for the lower angle of the sun in the winter season.(Fig-3) This system is more expensive than the fixed mount but it increases the solar panel power output by approximately 25%, thus making it more efficient.



Figure 3. Adjustable Solar Panel Mount

The tracking solar panel mounting system is the most expensive of the three types of mounting.(Fig-4) It tracks and follows the path of the sun (east to west) during the day as well as the seasonal declination movement of the sun. The tracking solar panel output increases by approximately 25% - 30%. It cannot be denied that this type of mounting is the most efficient in producing the greatest amount of solar power.



Figure 4. Tracking Solar Panel Mount

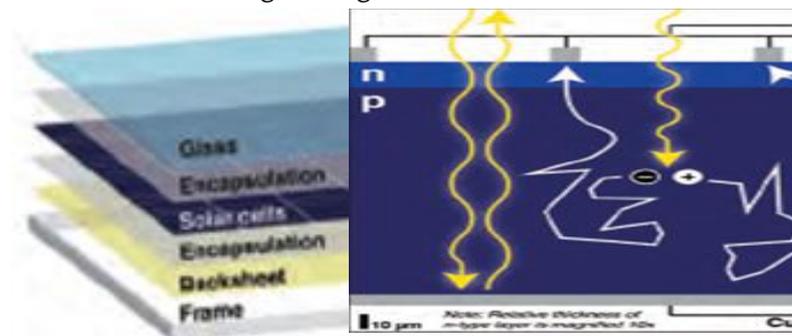
II. PHOTOVOLTAIC TECHNOLOGY

Solar photovoltaics are the most widely deployed solar electric technology in the world today. Photovoltaics are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons by the photovoltaic effect. [6] There are three

primary technological trends can be identified that will be crucial for enabling large-scale photovoltaics .

2.1 Solar PV Energy Conversion :

A solar photovoltaics array consists of one or more electrically connected photovoltaics modules each containing many individual solar cells integrated with balance-of-system (BOS) hardware components, such as combiner boxes, inverters, transformers, racking, wiring, disconnects.



Breakout view of photovoltaics module

Cross section of silicon solar cell showing photovoltaics mechanism

Figure 2.1. Solar photovoltaics Energy Conversion

Figure 2.1 shows a complete solar photovoltaics system along with cross sections of a module and a cell. In a grid-connected system, combiners, inverters, and transformers convert the low-voltage direct current (dc) output of many individual photovoltaics modules into high-voltage alternating current (ac) power that is fed into the grid. A typical silicon (Si) PV module consists of a glass sheet for mechanical support and protection, laminated encapsulation layers of ethylene vinyl acetate (EVA) for ultraviolet (UV) and moisture protection; 60 to 96 individual 6-inch-square (15-cm-square) solar cells, each capable of producing 4-5 watts under peak illumination (Wp); an aluminum frame for mounting. Common module dimensions are 1 meter by 1.5 meters by 4 centimeters, and peak power ratings range from 260 W to 320 W. Solar photons are transmitted into each cell, and those photons with sufficiently high energy (i.e., higher than the material-dependent energy bandgap) are absorbed.[8] An absorbed photon transfers its

energy to an electron and its positively charged counterpart (a hole). An internal electric field pulls electrons toward one electrode and holes toward the other, resulting in a dc electric current. See Appendix B for a more detailed discussion of the PV conversion process.

2.2 PV Technology Options:

Solar cell technologies are typically named according to their primary light-absorbing material. As shown in Figure 2.2, PV cells can be classified as either wafer-based or thin film. Wafer-based cells are fabricated on semiconducting wafers and can be handled without an additional substrate. Thin-film cells consist of layers of semiconducting material deposited onto an insulating substrate, such as glass or flexible plastic. The thin-film PV category can be further divided into commercial and emerging thin-film technologies. A more nuanced PV classification scheme is presented in the next section. Silicon can be manufactured into non-toxic, efficient, and extremely reliable solar cells, leveraging the cumulative learning of more than 60 years of semiconductor processing for integrated circuits. Crystalline silicon (c-Si) solar cells are divided into two categories: single-crystalline (sc-Si) and multi-crystalline (mc-Si). [10]

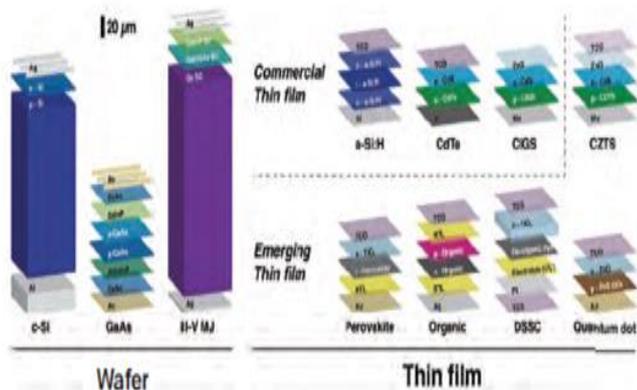


Figure 2.2 Solar Photovoltaic Device Structure

2.3 Current development:

For best performance, terrestrial PV systems aim to maximize the time they face the sun. Solar trackers achieve this by moving PV panels to follow the sun. The increase can be by as much as 20% in

winter and by as much as 50% in summer. Static mounted systems can be optimized by analysis of the sun path. Panels are often set to latitude tilt, an angle equal to the latitude, but performance can be improved by adjusting the angle for summer or winter. A number of solar panels may also be mounted vertically above each other in a tower, if the zenith distance of the Sun is greater than zero, and the tower can be turned horizontally as a whole and each panels additionally around a horizontal axis. In such a tower the panels can follow the Sun exactly.[6] Such a device may be described as a ladder mounted on a turntable disk. Another recent development involves the makeup of solar cells. Perovskite is a very inexpensive material which is being used to replace the expensive crystalline silicon which is still part of a standard PV cell build to this day. Michael Graetzel, Director of the Laboratory of Photonics and Interfaces at EPFL says, "Today, efficiency has peaked at 18 percent, but it's expected to get even higher in the future. This is a significant claim, as 20% efficiency is typical among solar panels which use more expensive materials."

2.4 Efficiency of PV

The electrical efficiency of a PV cell is a physical property which represents how much electrical power a cell can produce for a given insolation. The basic expression for maximum efficiency of a photovoltaic cell is given by the ratio of output power to the incident solar power (radiation flux times area)

$$\eta = \frac{P_{\max}}{E \times A_{\text{cell}}}$$

The efficiency is measured under ideal laboratory conditions and represents the maximum achievable efficiency of the PV material. Actual efficiency is influenced by the output Voltage, current, junction temperature, light intensity and spectrum

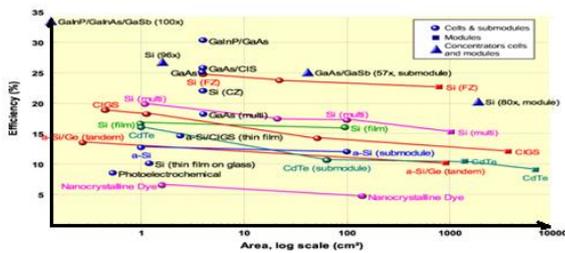


Figure 3

There is an ongoing effort to increase the conversion efficiency of PV cells and modules, primarily for competitive advantage. In order to increase the efficiency of solar cells, it is important to choose a semiconductor material with an appropriate band gap that matches the solar spectrum. This will enhance the electrical and optical properties. Improving the method of charge collection is also useful for increasing the efficiency. There are several groups of materials that are being developed. Ultrahigh-efficiency devices ($\eta > 30\%$) are made by using GaAs and GaInP₂ semiconductors with multijunction tandem cells. High-quality, single-crystal silicon materials are used to achieve high-efficiency, low cost cells ($\eta > 20\%$). Recent developments in Organic photovoltaic cells (OPVs) have made significant advancements in power conversion efficiency from 3% to over 15% since their introduction in the 1980s. To date, the highest reported power conversion efficiency ranges from 6.7% to 8.94% for small molecule, 8.4%–10.6% for polymer OPVs, and 7% to 21% for perovskite OPVs. OPVs are expected to play a major role in the PV market. Recent improvements have increased the efficiency and lowered cost, while remaining environmentally-benign and renewable.

1) 2.5 Growth of PV:

Solar photovoltaics is growing rapidly and worldwide installed, assume capacity reached about 300 gigawatts (GW) by the end of 2016.[9] Since 2000, installed capacity has seen a growth factor of about 57. This represents 1% of worldwide electricity demand. More than 100 countries use solar PV. China, Japan and the US is now the fastest

growing market, while Germany remains the world's largest producer, contributing more than 7% to its national electricity demand.[9] Photovoltaics is now, after hydro and wind power, the third most important renewable energy source in terms of globally installed capacity.

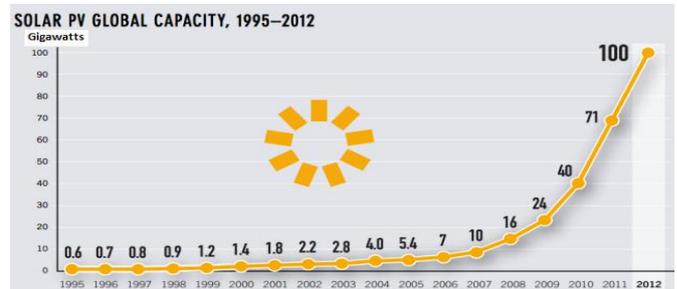


Figure 4

Several market research and financial companies foresee record-breaking global installation of more than 50 GW in 2015. China is predicted to take the lead from Germany and to become the world's largest producer of PV power by installing another targeted 17.8 GW in 2015. India is expected to install 1.8 GW, doubling its annual installations.[10] By 2018, worldwide photovoltaic capacity is projected to double or even triple to 430 GW. Solar Power Europe (formerly known as EPIA) also estimates that photovoltaics will meet 10% to 15% of Europe's energy demand in 2030 global PV installed capacities will be between 3,000 and 10,000 GW. The EPIA/Greenpeace Solar Generation Paradigm Shift Scenario (formerly called Advanced Scenario) from 2010 shows that by the year 2030, 1,845 GW of PV systems could be generating approximately 2,646 TWh/year of electricity around the world. Combined with energy use efficiency improvements, this would represent the electricity needs of more than 9% of the world's population. The costs of power from wind and solar are already below those of conventional electricity generation in some parts of the world, as they have fallen sharply and will continue to do so. In addition, worldwide electricity prices came under strong pressure from renewable energy sources, that are, in part, enthusiastically embraced by consumers.

III. CONCLUSION

Predicting the future development of any technology is inherently fraught with uncertainty. While silicon technology dominates the PV market today, alternative technologies are evolving rapidly. The solar cell of the future may be a refined version of current commercial cells or an entirely new technology. Furthermore, global installed PV capacity today is a minuscule fraction of expected future deployment. Few if any industries have grown as fast or as unpredictably as the PV industry in recent years. Faced with uncertain technological change and uncertain economic pressures, we view all technologies through the objective lens of application-driven performance metrics. These metrics point to three technical trends: increased efficiency, reduced materials usage, and reduced manufacturing complexity and cost that technology leaders should target in their R&D efforts. Focusing on the unique strengths and potential applications of solar PV will help to identify windows of opportunity for future PV technology development and deployment.

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