A REVIEW OF DIFFERENT SOLAR PHOTOVOLTAIC TECHNOLOGIES AND THEIR IMPLEMENTATION WILL BRING THIS FUTURE TO FRUITION

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ABSTRACT

As we all know that energy is essential for growth of any society or for their economic development of any society. Typically, in order for solar energy to work efficiently and supply energy to a building, a very large amount of space is required, in the form of rooftops or land, in order to install solar panels. These solar panel space requirements are a large impediment to practical usage. This drawback drove researchers to come up with transparent solar cells (TSCs), which solves the problem by turning any sheet of glass into a photovoltaic solar cell and also turned up with new upllіftments in solar cell technologies.

Index Terms*:-Renewable energy, Tends and concepts of PV cells and Transparent solar cells.*

NOMENCLATURE

SCPP Solar Chimney Power Plant
CSCP Conventional Solar Chimney Power Plant
PV Photovoltaic
PVSCP Photovoltaic based Solar Chimney Power Plant
PVDSCP Photovoltaic and Desalination based Solar Chimney Power Plant
SCPP Solar Chimney Power Plant
TPV transparent photo voltaic
TDSSC transparent dye synthesis solar cell
DSSC Dye synthesised solar cell
EPD Electrophoretic deposition
TFSC Thin film solar cell
TLSC Transparent luminescent solar concentrator
QD Quantum dot
TSC transparent solar cell
ITO Indium-doped tin oxide
TFPV Thin film Photovoltaic

1. INTRODUCTION

In recent times many new technologies has been developed so the concern is that, which are the technologies that can be implemented or types of technologies in the market and comparatively among those which one is better efficient [1] [2].All the day sun sends out appalling amount of energy in the form of heat and radiations called solar energy. It is a limitless source of energy which is available at no cost [7] [10]. The growth of solar cells began with the discovery of single crystal silicon solar cells in 1954 at Bell Labs. Thereafter, research continued to make progress, and during the epoch spanning the latter half of the 1950s through the beginning of the 1960s, this technology began to be utilized in high value applications such as the power supply for a man-made satellite [6] The major benefit of solar energy over other conventional power generators is that the sunlight can be directly harvested into solar energy with the use of small and tiny photovoltaic (PV) solar cells [7] [10]. With the 1974 oil crisis as an impetus, major research projects in Japan [including the Sunshine Program sponsored by the Ministry of International Trade and Industry] were initiated for power applications [6].

There are many factors affecting TSC below are some major considerable points while selecting transparent solar cell:

- Photovoltaic Glass
- Solar Glass
- Strength of Solar glass
- Durability of solar cell

The photovoltaic cells faces the challenges of cost, efficiency, and operating lifetime, Researchers are now trying or focusing on finding materials that will overcome these challenges [2].

2. PHOTOVOLTAIC PRINCIPLE

In 1839, photovoltaic (PV) effect was first observed by Alexandre-Edmond Becquerel and in 1946 the first modern solar cell made of up of silicon was invented by Russel Ohl. Previously photovoltaic solar cells were thin silicon wafers that transform sunlight energy into an electrical power [7]. The PV cell which has semiconductor material absorbs photons (light), and this moves electrons to form pairs of electrons and holes, which are showed in one direction, creating a current. The semiconductor is doped to be a p-n junction with a potential difference, which will drive current flow vertically through the cell in one direction, so it can be garnered as electricity. The diffusion length is one of the important factors that affect the efficiency of the solar cell. Photons must have energy equivalent to or more than the energy band gap of the semiconducting material [1] [2]. Photovoltaic cell is a device that converts sunlight into electricity using semiconductor materials.

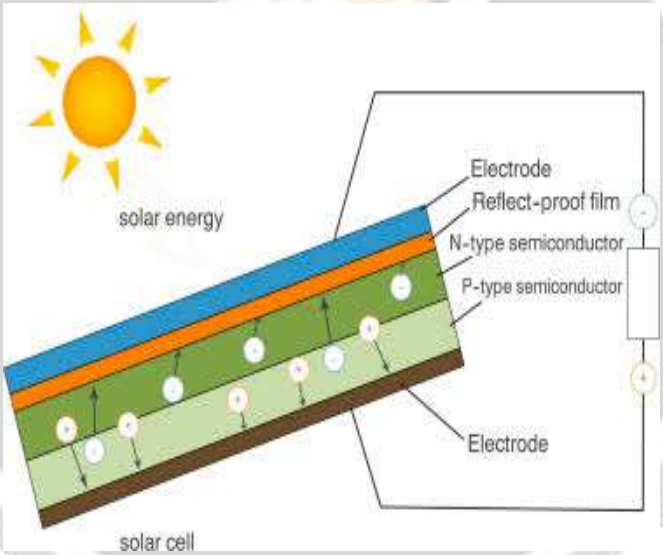


Fig-1 Cross section of transparent solar cell

It has the same operational principle as a semiconducting diode. The semiconductor material, such as silicon, has the property to eject electrons when sunlight is engrossed; the PV's cell then directs the electrons in one direction, which forms a current. A thin film made up of dye molecules deposited on glass which absorb sunlight and that light is stuck and transported within the glass by total internal reflection until it is captured by solar cells mounted on the edges of the glass [2] as illustrated in Fig. 1

3. SOLAR CELLS

Now the photovoltaic solar cells can be classified or categorized into various classes as shown in Fig. 2 On the basis of these materials as discussed in the following sections. Here two technologies are discussed in brief and they are Dye sensitized solar cells and Pervoskite based solar cells.

3.1 DYE-SENSITIZED SOLAR CELLS (DSSC)

Current research has been engrossed on improving solar efficiency by molecular manipulation, use of nanotechnology for harvesting light energy and the first DSSC solar cell was announced by Michel Gratzel in Swiss federal institute of technology [7]. DSSCs based solar cells generally employ dye molecules between the

different electrodes. The DSSCs attractive due to the simple conventional processing methods like printing techniques, are highly flexible, transparent and low cost as well the novelty in the DSSC solar cells arise due to the photosensitization of Nano grained TiO2 coatings coupled with the visible optically active dyes, thus increasing the efficiencies greater than 10%.
The DSSC device consists of four components:

1. semiconductor electrode (n-type TiO2 and p-type NiO)
2. dye sensitizer
3. redox mediator
4. counter electrode (carbon or Pt)

However, there are certain challenges like degradation of dye molecules and hence stability issues so this is due to poor optical absorption of sensitizers which results in poor conversion efficiency[2][3][7]. The dye molecules generally degrade after exposure to ultraviolet and infrared radiations leading to a decrease in the lifetime and stability of the cells. Moreover, coating with a barrier layer may also increase the manufacturing more expensive and lower the efficiency [7].

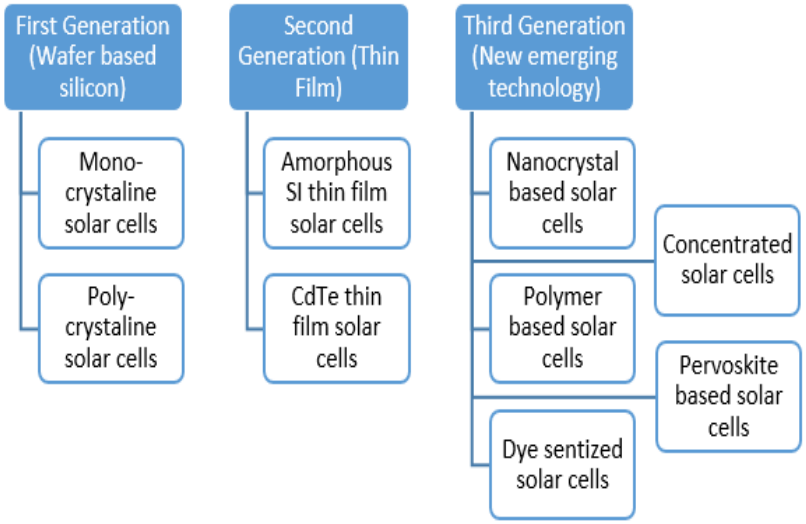


Fig-2 Catagarization of Solar cells

3.2 PEROVSKITE SOLAR CELL

Researcher's emphasis on enlightening the semi-transparent nature of organic solar cells by using an absorbing material that has a lower band gap than the photons, which means it will let for visible light through and absorb near infrared light [2]. Perovskites are a class of compounds distinct by the formula ABX3 where X represents a halogen such as I−, Br−, Cl−. and A and B are cautions of different size and they are fresh innovation among the solar cell research community and possess several advantages over conventional silicon and thin film based solar cells and the Si based solar cells need expensive, multiple handling steps and require high temperatures more than 1000˚C and it needs vacuums facilities[3][7]. The perovskites based solar cells can have efficiency up to 31% as per latest research [7]. It can be predicted that these perovskites may also play an vital role in next-generation electric automobiles batteries, according to an interesting investigation recently performed by a very well-known brand Volkswagen [7]. Hence By decreasing the thickness of wafer efficiency of solar cells can be increased [8].

4. TYPES OF TSCs

There are approximately nine technologies which are a focal point of current research due to market demand and that put on to the fabrication of transparent solar cells, and the probable applications of transparent solar cells (TSC). Some centres like Japan, USA, Germany and India shows success report on TSC. Here the considerable point is that 90% of these technologies uses an FTO or ITO conductor on a glass, which has a layer with almost 10 Ω/sq resistance, using a thin film with a thickness of less than 20 nm. Combined with intrinsic optical losses of the glass itself, it tends to reduction in transparency by approximately 15–20% before the deposition of any other materials. Thus, the best transparency achieved currently is less than 80% after the ample amount of vital research. So as per different research studies and novelty of innovation deals with new types of transparent solar

cells and can be categorised or classified in some following below manner. This below classification may not be having all but is the most and major types which are descried and explained which play dominant role.

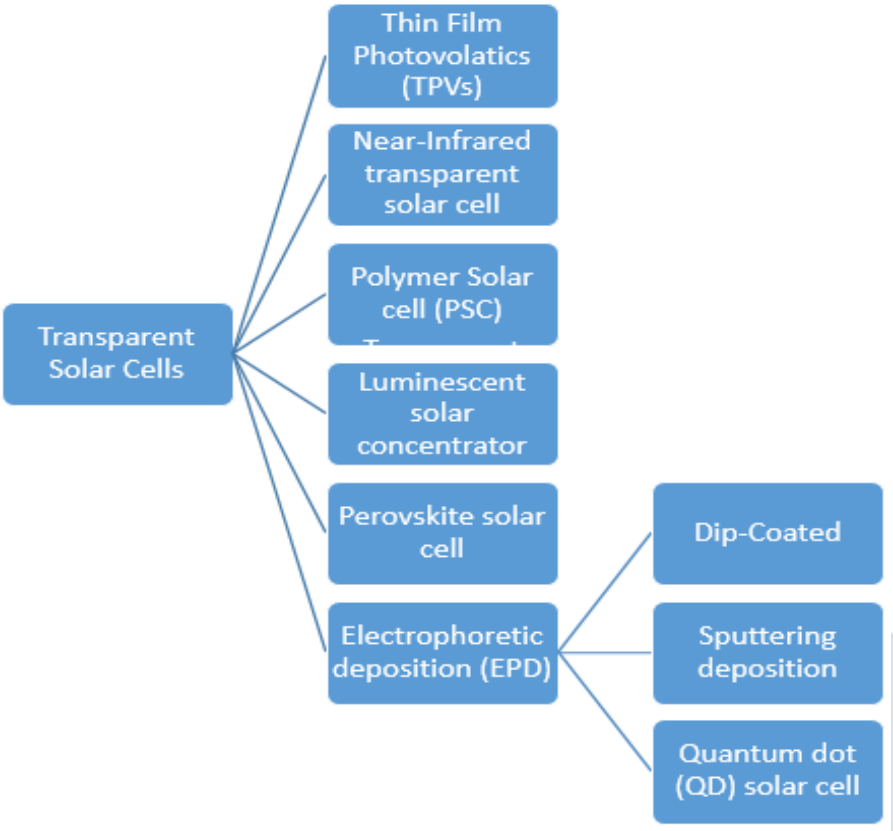


Fig-3 Types of TSC

5. IMPLEMENTATION OF SCPP INTEGRATED WITH TPV CELLS

This [4] includes study of two article configuration conventional solar chimney power plant integrated with transparent PV cells (PVSCP) and saline water distillation method (PVDSCP) Method for better use of solar energy and land resources for each configuration mathematical model has been developed by doing so it was found that all the results are +- 15 % band errors from the results, the PVDSCP has higher efficiency than CSCP and PVSCP. This technique or system can be implemented for performance enhancement of CSCP with advantages of relatively high plant efficiency, endless capacity, low cost, no pollution, and simple structure [4]. Fossil fuels are very rich in utilization from many years due to which, growth of energy consumption rate and climate issues are increased day by day.

To overcome this or balance this, new methods are developed by scientist or researchers from that one of the recognised technique is solar chimney power plant (which increase plant efficiency by utilizing solar energy). Two methods can implemented in SCPP. They are PVSCP and PVDSCP but question is that at which method has better efficiency. By using mathematical logic a mathematical model is prepared from which some constrains are recognised and equation of efficiency derived. Following assumptions were made for modelling:

1. Frictional effects are negligible.
2. As the flow has very low Mach number, the contribution of kinetic energy is ignored.
3. Meteorological data (i.e. solar radiation, ambient temperature and wind speed) are assumed to be constant for having a fair comparison basis of various models.
4. Models are solve under steady state conditions.

Working fluid (i.e. air) obeys ideal gas laws and glazing thicknesses are thin. Here we will discuss three cases which itself have their own unique meaning in their same liking parameters. Those modelling detail is not describe in deep due to some limitation but central idea can understood by the state of knowledge reader. While

considering those below cases do not forget to those above assumptions. Different dimensional modelling efficiency equations are as below:

(1) CSCP

$$\eta_{CSCP} = \eta_{chi}\ \eta_{tb}\ \eta_{col}$$

Above equation of efficiency is nothing but the product of three different efficiencies and those efficiencies can be written as follows.

$$\eta_{coll,\ CSCP} = \frac{mCP_1(T_2-T_1)}{q_{CSCP}\ A_r}$$

$$A = \pi({r_r}^2 - {r_e}^2)$$

$$\eta_{tb,\ CSCP} = \frac{W_{tb}(\rho_2-P_3)}{2m(P_2-P_3)}$$

$$\eta_{chi,\ CSCP} = \frac{gh_c}{CP_1\ T_1}$$

tb = Turbine ; chi = Chimney ; col = Collector

(2) PVSCP

$$\eta_{PVSCP} = \eta_{chi}\ \eta_{tb}\ \eta_{col}$$

Here

$$\eta_{coll,\ PVSCP} = \frac{q_{PVSCP} + P_{PV}}{E_{in}}$$

Because here selection & modelling of transparent cell is different from CSCP

(3) PVDSP

$$\eta_{PVDSP} = \eta_{chi}\ \eta_{tb}\ \eta_{col}$$

Here,

$$\eta_{coll,\ PVDSP} = \frac{q_{PVSCP} + q_{basin} + P_{PV}}{E_{in}}$$

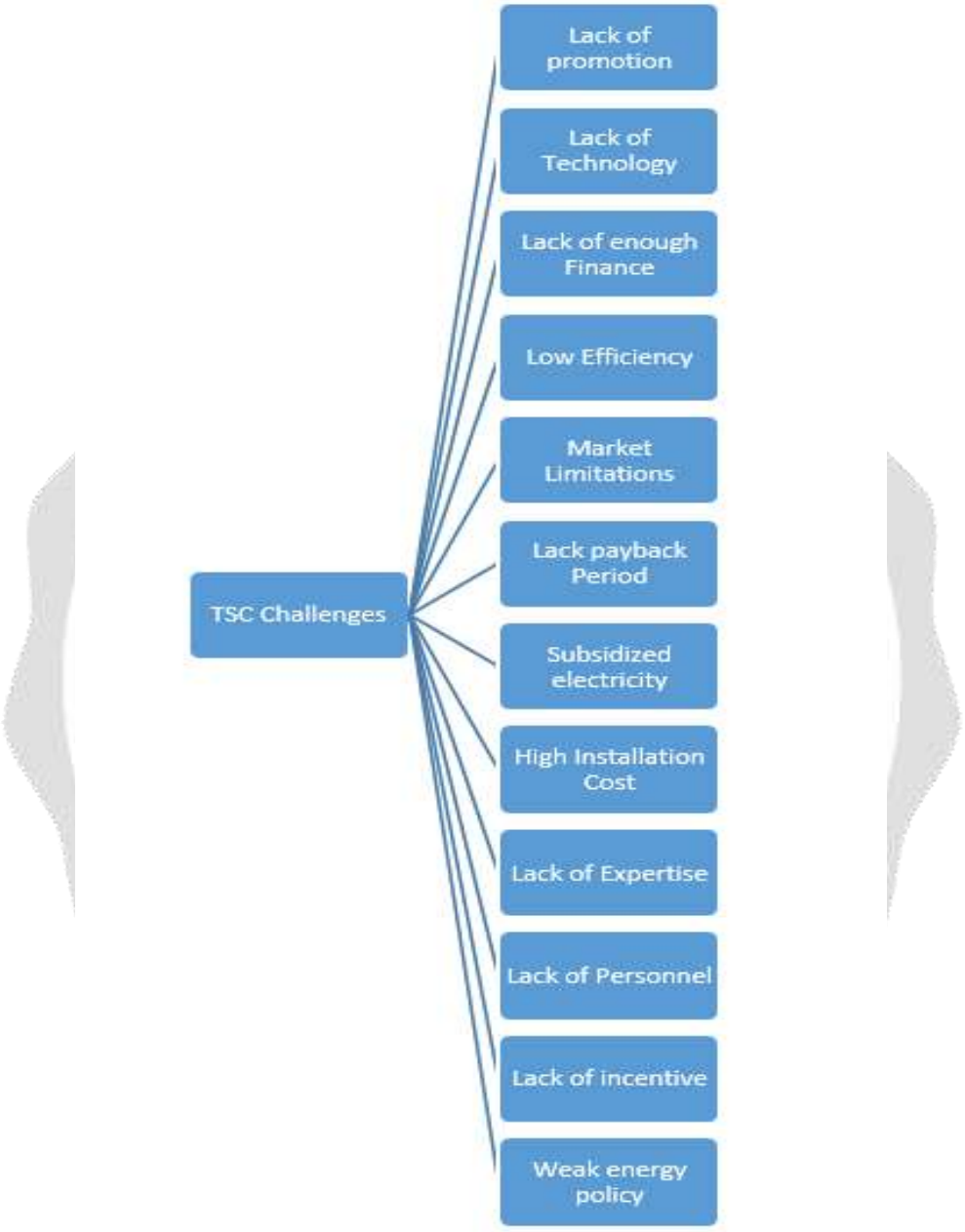
In above all three cases all the equations have their different mathematical modelling equations so it is better to be specify for all the three cases. All comparative results it is found that PVDSCP is more convenient than other two. By Deriving required equations of efficiency we can have a rough idea which method can be implemented and which not but then also the result of that equations are 15% error so in future exact equation can be mode[4]. By summarizing or recreating those assumption which were taken in beginning of the equations.

Table-1 Comparison between different technologies

Cell Type	Efficiency (%)	High Temperature Performance	Cost	Installation Time	Space
Amorphous Silicon	4-8	Good	50 % < CSC	Long	Large
Nano-crystal	7-8	Excellent	50 % < CSC	Short	Large
Dye Sensitized	9-10	Not good	50 % < CSC	Short	Large
Polymer	2-10	Not good	50 % < CSC	Short	Small
Concentrated	38-40	Excellent	50 % < CSC	Long	Large
Perovskites	31	Excellent	50 % < CSC	Long	Minimum

6. TSC FUTURE RESEARCH OPPORTUNITIES

Various countries of the world like Germany, Japan, India, Spain, China and United States, they are now started their work of research and development by government support and awareness, hence there is a great need to start an industry as it is already started in European countries. However, in tropical countries this technologies are rarely used. There are some point worthy labels which are the challenges to the transparent solar cells



technologies [5] and they are illustrated in Fig. 4

Fig- 4 Challenges of the TSC technologies

7. CONCLUSION

Solar energy generation is one of the demanded alternative to the other form of sources like fossil, petroleum, etc. The main problem remains that the payback period of after installation of the system of transparent solar cell cannot be predicated from this minimal data so a proof-full technique need to be develop for its effective use and awareness. If transparent solar cells are made satisfactory to all economical and technical concern than

it this upliftment will bring this future to fruition. This technologies should be adopted by industrial sector (which is one of the most capable entity in the society) not because of their profit but for the awareness and advancement in technology. The carving recent latest technologies of solar cell there are several issues with that but major which can be considerable in priority are Durability and stability so it need more research to fetch them in market place.

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