# REVIEW ON PHTOVOLTAIC TECHNOLOGY BASED POWER GENERATION

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## ABSTRACT

*Depleting sources of conventional energy and ever increasing requirement of energy across the globe while keeping in mind the environmental protection issues have given rise to massive research in the field of Solar Power Generation using photovoltaic technology. Solar energy provides environment friendly and abundant energy resource to mankind. This paper reviews the research and development made in PV technology in general and its status in India in particular. Attempts have been made to highlight the application of various materials used for this technology.*

***Keywords: Depleting Sources, Photovoltaic Technology, Conventional Energy, Environment, Solar Power***

## I. INTRODUCTION

Self-sufficient energy requirement,decreasing sources of conventional energy and increasing demand of energy while caring issues related to environment have resulted massive research in PV power generation.The growing population globally together with the trend of industrialization have increased the demand for energy and electricity. Use offossil fuels and nuclearpower as source of conventional energy, have given rise to several environmentalproblems. Greenhouse effect and acid rainwhich are the results of combustion of fossil fuels have imposed a threat to our climate. Radioactive waste disposal isa serious problem associated with the use of nuclear power. Thereforeit is need of the hour to find environment friendly sources and energy saving technologies for the mankind.

Photovoltaics are one such alternative which is clean and most suitable source of non-conventionalenergy. Solar cells directly convertsunlight into electrical power. For a country like India where power generation is required in remote area at affordable price, Photo voltaic power generation and similar non-conventional energy systems arebetter choices for low and medium levels of electricitypower generation [11,16,17]. Moreover the continuouscost effectiveness of photovoltaicarrays and their increasing efficiency ensure a promising role forphotovoltaics in power generation [21,45]

In India, per capita consumption growth of energy and installed generating capacity has not been proportional to each other. [2]Per capita use of energy increased to 813.3 kWh from 16.3 kWh while the installed capacity increased to 190 GW from 1362 MWin last sixty years[2]. Electric power generation is mainly dependent on fast depleting sources coal, oil and gas. Thereis littlecontribution of hydro and renewable sources in power generation ascompared to other fuels [40]. The present trendsuggests that India will have to invest heavily in

importing coal and other fuels to meet its futuredemandsas 18% of its villages are still not electrified at the present level of installed capacity of 190 GW[22].

Whereas with 5109 GWh per year energy incident over land surfacearea ,India has a great potential of untapped solar energy.Renewable energy sources, however contributes about 11.66% to the total installed power generation [41].In view of this, Government of India, launched a national mission in 2009to encourage an environment for Photovoltaic based technology, [37]. Photovoltaiccontribution is likely to be increased with better energy conversion efficiency and low cost PV power generation.

This paper, deals with a discussion on solar power generation mentioningdifferent photovoltaic materials, theirtechnicalconsiderations and important issues as mentionedby the researchersfor the practical realization of PV technology for use ofsolar energy power generation at low cost and better efficiency especially for the country like India.

## II. HISTORICAL BACKGROUND\

Photovoltaic effect was discovered by Becquerel in 1839[38]. Adams and Day [39] observed this effect in 1877 using solid Selenium. Fritz's first photovoltaic cell was developedwith efficiency lesser than1% in1883 [43]. Einstein published a paper on photovoltaic cell in1904 [39].In1941,Ohldeveloped the siliconphotovoltaic cell. TheseSilicon photovoltaic cell were refined to obtain efficiency of 6% in direct sunlight and lateron increased to 11% by Bell laboratories in 1954 [43].Initially scientists remained more interestedin getting as much electricalpower as possible from photovoltaic solar cells, and their cost was not of much importance to them [25]. However, later onwithindustrial productionand availability ofintermediate marketallowed the PV Market to growcontinuously [12]. PresentlyPV technology is relatively expensive technology, however with the decreasing cost of solar powergeneration, markets are growing [7].

## III. APPLICATIONS

Solar energy is pollution free, renewable and abundant in nature therefore it becomes an important non-conventional energy source. Direct conversion of sunlight into electricity by means of semiconductor devices, , application in space program, Lesser maintenancecost, longer life, reliability, better responses in output to input radiation changes, power maintainingcapabilities from microwatt to MW are various applications.The requirement of energy storage is thelimiting factor in the use of solar energy for different applications [24]. Application of photovoltaic power generation in remote areas wherepower requirements are smalland layingof distribution lines is not feasibleis increasing [29,30]

## IV. THE BASIC PHOTOVOLTAIC TECHNOLOGY

Solar cell is the main component of a photovoltaic system. A solar cell is made up of two or more layers of particular semiconducting material. The atoms of semiconductor absorb light, elections are made free and holes are created and it results in conduction of current. The junction between two different semiconductorsdevelops a potential difference to carry out current in the circuit. Solar cells can be designed with semiconductors havingdifferent physical stateslike-single crystal, polycrystalline crystals, amorphous or polycrystalline thin films .Solar cells are connected together in the form of a module. Arrays are formed when modules are grouped together depending upon power requirement

## V. EFFICIENCY AND COST

R&D in the area of photovoltaics has made the PV systems more competitive and affordable in the market. Life, efficiency, reliability and cost of devices are the key words for the preference ofthis system Device efficiency which is the ratio of the electrical output power to the incident solar power, is governed by absorption of light andloss mechanisms.Quality and kind of semiconductor,charge recombination at the junction, thetype of contacts, surface quality and interfaces, reflection of light and series and contact resistances act as limiting factors[44].Thekind and quantity of substrate material, design and fabrication techniques, choice of substrates, device design, and fabrication processes determine the cost of these devices.

## VI. PHOTOVOLTAIC MATERIALS

### 6.1 Crystalline Silicon

Crystalline silicon has been most widely used material for PV Technology. New methods have been evolved to get pure and high quality crystalline Silicon[19].Efficiency of 22.8% and 28.2% under ordinary light and concentrated sunlight respectively have been reported for crystalline silicon[33]It was reported that efficiency can be increased to 30% and 36% under ordinary and concentrated sunlight respectively under ideal conditions by ignoring losses [28]. Efficiency of 31% was also reported for Single junction Silicon Cells [32]. Apart from single crystal cells, polycrystalline silicon cells have also been grown and were found almost as efficient as single crystal cells however their production cost is less[27].Efficiency of 15% for polycrystalline silicon cell have been reported[14]. There is substantial increase in throughput with the incorporation of webprosessing and because of which there is significant increase in the production ratereported [14].Industry is working on the processes towards cost reduction of polycrystalline silicon cells and increasing their efficiency more than 19% [4]

### 6.2 Hydrogenated Amorphous Silicon

The first hydrogenated solar cell was reported in 1973[8,9].Due to its high photoconductivity and optical absorption ,amorphous silicon became promising alternative to single crystal and polycrystalline silicon [31,34].Since amorphous silicon is highly photo absorbent, its layers could be deposited on less expensive substrates like glass or plastic. However these devices lost efficiencies during the initial exposure due to presence of dangling bonds [42].To overcome low efficiency, multijunction devices of amorphous silicon have been reported. Cells of different materials having different bad gaps were stacked on each other. This configuration enhanced their efficiency up to 17% for two junction and up to 24% for three junction cell [20]. Theoretically their efficiency were estimated as 29 and 34 % respectively.[13].

### 6.3 Polycrystalline Thin Films

Copper indium diselenide,Copper indium gallium diselenideand cadmium telluride polycrystalline thin filmsare widely studied for photovoltaic applications[36,46].The efficiency reported so far under laboratory conditions for small size thin film based solar cell is 18.8%(34).At the production level ,CIGS module have been fabricated with efficiency between 9 and 12%(3).Theyhave advantages of amorphous silicon like high opticalabsorption coefficient.little material is required, and are suitablefor latest manufacturing processes. The problem of light induced degradation is not observedand can be fabricated with deposition techniques. Incomparison to amorphous silicon which employs glow discharge and plasma chemical vapordeposition (PCVD) techniques,

the vapor deposition methods like electrodeposition and electropyrosis used for CuInSe2 and CdTe are less expensive and much faster promising methods.

### 6.4 III-V Materials

Gallium arsenide(GaAs) and Aluminum gallium arsenide(AlGaAs) provide the highest solar cell efficiency. For single junction cell of GaAs, the highest theoretical efficiency of 39% has been reported [1] . When used as single crystal thin cell ,GaAs provides an efficiency of 22.4%[36]. This device was found to be efficient as well as inexpensive.GaAs single crytal thin films are being grown on reusable GaAs substrate. Multijuntion Designs using alloys of GaAs like AlGaAs and InGaAs have been successfully fabricated. Such designs match the lattice constants and have ability to attain efficiency in the range of 35% to 40%.Still the cost of these devices remain expensive and competitive in the markets [14,15]

6.5 ORGANIC SEMICONDUCTOR MATERIALS

Micro and optoelectronic devices have applications of these materials. The Physics of organic semiconductors however still follows their application. The difference in doping mechanism, charge behavior and energy transport between conventional semiconductor and organic semiconductor provides a need for exact understanding of device physics [6] of organic solar cell . In heterojunction organic solar cell, photo generated charge pairs are separated and transported to carry photocurrent to opposite electrodes [26,10] at the interface.

## VII. CONCLUSION

The role of new and renewable energy towards Energy self-sufficiency in Indiais immense. Keeping this in viewJawaharlal Nehru National Solar Mission was launched by the Prime minister of Indiain 2010with the ambitious target of adding 20,000 MW of grid connected solar power by 2022[23]. Main objective is to reduce the cost of solar power generation in the country throughvarious means. Solar PV power generation has a very high potential as a clean, environment friendly alternative to conventional power generation, however their efficiency and manufacturing cost have not reached to the level where it can replace the conventional power generating facilities. To make this technology affordable for long term benefit, more innovative research in terms of device design,reliability,use of materials, and increasing efficiency has to be carried out in future.

## REFERENCES

[1] Araujo, G. L., & Marti, A. (1988). 20th IEEE Photovoltaic Specialist Conference. IEEE,New York. New York.

[2] 2Authority, C. E. (June, 2011). Growth of electricity in india from 1947 to 2011. New Delhi: Ministry of Power, Govt. of India.

[3] B.Dimmler. (1998). 2nd World Conference on PV Solar Energy Conversion. Viena.

[4] Barnett, A. (1988). Proceedings of the 8th International E.C. Photovoltaic Solar Energy Conference,. Proceedings. Norwell,MA: Kluwer Academic.

[5] Bhubaneswari Paridaa, S. I. (2011). A review of solar photovoltaic technologies. Renewable and Sustainable Energy Reviews, 15, 1625-1636.

[6] Borsenberger PM, W. D. (1998). Organic Photoreceptors for Xerography. Boca Raton,FL: CRC Press.

[7] Burns J.EBurns JE, K. J. (2012). Comparative economic analysis of supporting poComprhensive economic analysis for supporting policies for residential solar. PV in the United States: Solar Renewable Energy Credit ... energy policy, 44(25), 217.

[8] C.R.Wronski, D. a. (1976). Amorphous Silicon Solar Cells. Appl.Phys.Lett., 28, 671-673.

[9] C.R.Wronski, D. a. (1977). Technology and Application of Amorphous silicon. Appl.Phy.Letts., 31, 292.

[10] Campoy-Quiles M, F. T. (2008). Morphology evolution via self-organization and lateral and vertical diffusion in polymer: fullerene solar cell blends,. Nat.Mater, 158-164.

[11] Chambouleyron, I. (1986). A Third World view of the photovoltaic market. Solar Energy, 36(5), 381–386.

[12] Coiante D, B. (1992). Can photovoltaics become an effective energy option. Solar Energy Materials And Solar Cells, 27(89), 79.

[13] Dalal, V. L. (1984). 17th IEEE Photovoltaic Specialists Conference, Kissimmee, FL,., (pp. . 86-91). FL.

[14] Energy, D. o. (1987). DOE/CH/10093-H3. Solar Energy Research Institute,Golden,CO.

[15] energy, D. o. (n.d.). Department of Energy report DOE/CH10093-7. Solar energy research institute.

[16] Enslin, J. H. (1992). Maximum Power Point Tracking: A Cost Saving Necessity in Solar Energy Systems. Renewable Energy, 2(6), 543-549.

[17] G.K.Singh. (2013). Solar Power Genaration By PV(photovoltaic)technology:A review,. Energy, 1-13.

[18] Grätzel, M. (2007, april 15). Photovoltaic and photoelectrochemical conversion of solar energy. Philosophical Transactions: Mathematical, Physical and Engineering Sciences, 365(1853), 993-1005.

[19] H.M.Hubbard. (1989). Photovoltaics Today and Tomorrow. Science, 244(4902), 297-304.

[20] J. C. C. Fan, B.-Y. T. (1983). 16th IEEE Photovoltaic Specialists C onference,. IEEE, (pp. 692-702). SanDiago.

[21] K.H. Hussein, I. M. (1995). Maximum photovoltaic power tracking : an algorithm for rapidly changing atmospheric conditions. IEE Proceedings on Generation, Transmission, Distribution, 142, pp. 59-64.

[22] Kelly, H. (1978, feb 10). Photovoltaic Power Systems:A Tour Through the Alternatives. Science, 199(4329), 634-643.

[23] Kumar, K. A. (2014). Performance study on a grid connected 20kWp solar photovoltaic installation in an industry in Tiruchirapalli(India. Energy for Sustainable Development, 23, 294-304.

[24] Kumaresan G, S. R. (2012). performance studies of a solar parabolic trough collector with a thermal storage system. Energy, 47(402), 395.

[25] M., H. (1998). Getting power from the sun: solar power. Chemistry and. Industry, 28(6), 219.

[26] McGehee, M. (2009). Organic solar cells: Overcoming recombination. Nature Photonics, 3, 250-252.

[27] P. Maycock. (1988). In Photovoltaic Technology Performance,cost,and market forcast. CASANOVA: Photovoltaic Energy System.

[28] P.Campbell, M. (1986). Proceedings. In IEEE (Ed.), 18th IEEE photovoltaics specialist Conference,1985. Las Vegas: IEEE,New York.

[29] Penick T, L. B. (1998). Photovoltaic power generation. GaleGreenLeaf.

[30] Quesada B, S. C. (2011). Experimental results andsimulation with TRNSYS of a 7.2 kWp grid-connected photovoltaic system. applied energy, 88(83), 1772.

[31] R. C. Chittick, J. H. (1969). The Preparation and properties of amorphous silicon. J.Electrochem.Soc., 116(1), 77-81.

[32] R.M.Swanson. (1989). SCIENCE, 156-163.

[33] (1989). Report DOE/CH10093-40. Department of Energy. Golden,CO: Solar Energy Research Institute,.

[34] Shah, A. (1999, Jul). .,Photovoltaic Technology:The case for Thin Film Solar Cells. Science, New Series, 285(5428), 692-698.

[35] Sharma, V. (2013). Performance analysis of a 190 kWp grid interactive solar photovoltaic power plant in India. Energy, 276-485.

[36] Tyan, E. A.-A.-S. (1980, may 23). ,Photovoltaic Materials. Science,New Series,, 208(4446), 901-907.

[37] website. ( 2010, JULY). Jawaharlal Nehru National Solar Mission.Guidelines for selection of new gridconnected solar power projects. Retrieved from Govt of India: www.mnre.gov.in

[38] website. (1998, october 21). Energy Conversion:development of solar cells. Retrieved from Britannica.online: Energy conversion: development of solar cells. Britannica. online, http://www.eb.com:180-cgi-bin/g? DocF¼macro/5002/13/245.html

[39] website. (1998, November 15). The history of PV. Retrieved from pv power: http://www.pvpower.com/pvhistory.html

[40] website. (2013, jan 12). Indian Electricity Scenario. Retrieved from ministry of power,govt of india: http://www.powermin.nic.in

[41] website. (2013, jan 12). Solar Resource Map of India. Retrieved from govt of india: http://www.nrel.gov/international/ra_india.html, :

[42] Wronski, D. L. (1997). Technology andApplication of amorphous silicon. Appl. Phy.Letts., 31, 292.

[43] Zweibel Kenneth, H. P. (1984). Basic Photovoltaic Principles and Methods. New York: Van Nostrand Reinhold,.

[44] Zweibel, K. (1984). Basic Photovoltaic Principles and Methods. Florence, USA: Van Nostrand Reinhold.

[45] Zweibel, K. (1990). Harnessing solar power,the photovoltaic challenge. New York, USA: Plenum Press.

[46] Zweibel, K. (1993, july-aug). Thin Film Photovoltaic Cells. American Scientist, 81(4), 362-369.