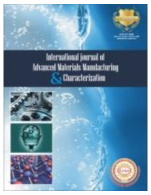

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# Materials used for Renewable energy resources

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A R T I C L E  I N F O

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A B S T R A C T

The global demand for energy is currently growing beyond the limits of installable generation capacity. To meet future energy demands efficiently, energy security and reliability must be improved and alternative energy sources must be investigated aggressively. An effective energy solution should be able to address long-term issues by utilizing alternative and renewable energy sources. Of the many available renewable sources of energy, solar energy is clearly a promising option as it is extensively available. . Solar energy is the most abundant, inexhaustible and clean of all the renewable energy resources till date. The power from sun intercepted by the earth is about $1.8 \times 10^{11}$ MW, which is many times larger than the present rate of all the energy consumption. Photovoltaic technology is one of the finest ways to harness the solar power. Solar power, especially as it reaches more competitive levels with other energy sources in terms of cost, may serve to sustain the lives of millions of underprivileged people in developing countries. Furthermore, solar energy devices can benefit the environment and economy of developing countries. This paper reviews the different materials used for solar energy absorption as a need for the utilization of alternative energy sources for the whole world and the importance of doing research in alternative energy resources.

## Introduction

Preventing an energy crisis is one of the most crucial issues of the 21st century. In the past, there has been a constant endeavor to find an alternate way to satisfy the growing energy needs of the global population–the vast majority still living in poverty–without plundering the resources that will be needed by future generations, polluting our ecosystems, and putting undue pressure on the energy-rich regions of the world. In achieving this, the first problem faced is the explosion in demand due to both the rapid increase in population and the efforts of the most densely populated regions of the world to develop their economies. In just one generation, the global population has increased by nearly 2 billion, with a major contribution from developing countries. Also, it is a known fact that energy demand increases at a rate that is proportional to economic growth. Based on this, the International Energy Agency (IEA) estimates that developing countries will need to double their installed generation capacity in order to meet the growing demand for power by the year 2020. In the International Energy Outlook (IEO) 2009 [1], the total world consumption of marketed energy is projected to increase by 44% from 2006 to 2030, as shown in Fig. 1. In spite of several initiatives, policies, and investments for increasing generation capacity, the number of non-electrified areas in developing countries has not changed significantly. Lack of access to electricity continues to be one of the major reasons that citizens of non-electrified communities are still poor [2]. Therefore, it is critically important to create the required infra-structure and install the needed distributed energy generation resources to satisfy global energy needs. Renewable energy is not a new concept, but it continues to rapidly emerge as an alternative to fossil fuels and other deleter- ious energy sources. The potential of renewable energy sources is enormous as they, in theory, can produce many times the world's total energy demand. For example, some studies have indicated that roughly 1000 times the global energy requirement can be fulfilled by using solar energy; however, only 0.02% of this energy is currently utilized [3]. Renewable energy sources such as biomass, wind, solar, hydropower, and geothermal can provide sustainable energy services based on the utilization of routinely available indigenous resources. A transition to renewable energy systems is increasingly likely as their costs continue to decline while the cost of fossil fuels continues to rise. In the past 30 years, solar and wind power systems have continued to improve their performance characteristics and have experienced rapid sales growth. The capital and generation costs associated with such systems have also been reduced significantly. Because of these developments, market opportunities now exist to both innovate and take advantage of emerging markets in order to

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promote renewable energy technologies, particularly with additional assis- tance of governmental and popular sentiment. The development and use of renewable energy sources can enhance diversity in energy supply markets, contribute to securing long term sustain- able energy supplies, help reduce local and global atmospheric emissions, and provide commercially attractive options to meet specific energy service needs. The use of renewable energy is also becoming increasingly important to slow the effects of climate change.

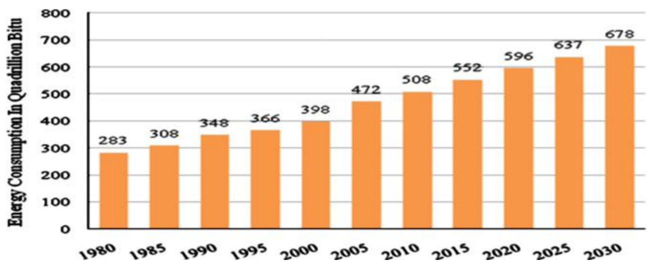



Fig.1. World marketedenergyconsumption1980–2030 [1].

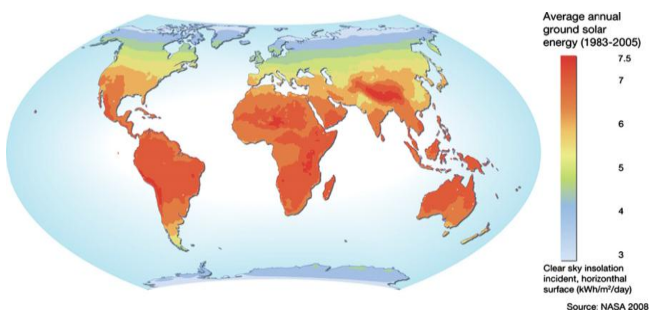


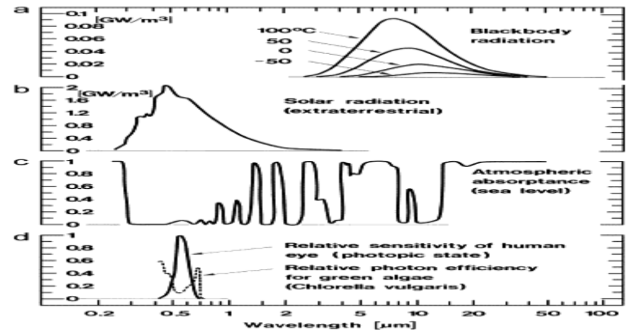

Fig. 2. Average annual global solar energy [4].

In the following systems the application of different materials have been described briefly by the author.

**Transparent conductors as solar energy materials**:

Transparent conductors (TCs) have a multitude of applications for solar energy utilization and for energy savings, especially in research organizations like DRDO(Defense Research Developent Organization), ADA and educational institutions.The spectrally selective materials are thin films based on metals (normally gold or titanium nitride) or wide band gap semiconductors with heavy doping (normally based on indium, tin, or zinc). Their applications to energy-efficient windows are covered in detail, experimentally as well as theoretically, and briefer discussions are given applications to solar cells and solar collectors mentioned in the journal of Solar energy and resources[5]. Photocatalytic and *thermochromic* and *electrochromic* properties, super-hydrophilicity and angular selective TCs, for which the angular properties are caused by inclined columnar nanostructures are to be considered in selection of materials. Special treatments are to be given for thermochromic materials based on vanadium dioxide and for electro chromic multi-layer structures (incorporating TCs as essential components) [6]

The following figures gives the principles of sputter deposition, wave lengths in micrometer and transmittance in percentage.




- Fig. 3. Spectra for (a) black-body radiation pertaining to four temperatures, (b) solar radiation outside the Earth's atmosphere, (c) typical absorptance across the full atmospheric envelope, and (d) relative sensitivity of the human eye and relative photosynthetic efficiency for green algae.(7).

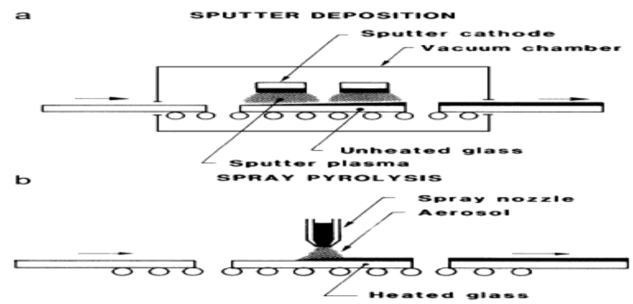



Fig. 4. Principles for sputter deposition (a) and spray pyrolysis (b) for coating surfaces of glass transported as indicated by the horizontal arrows(8)

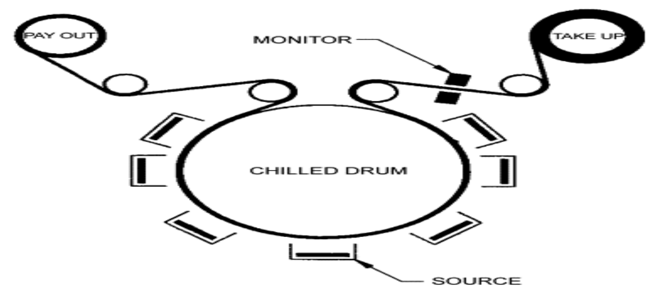
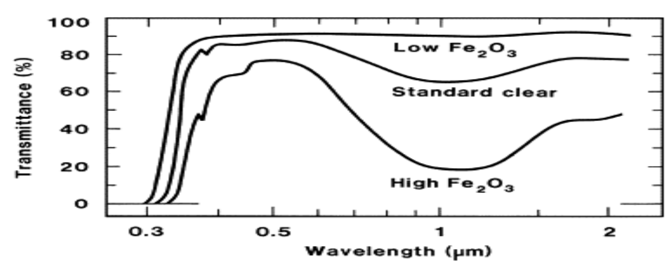



Fig. 5. Schematic diagram of the internal components of a roll-to-roll coater with several sputter cathodes.(9).




- Fig.6. Spectral transmittance for float glass with three different amounts of $Fe_2O_3$. (10)

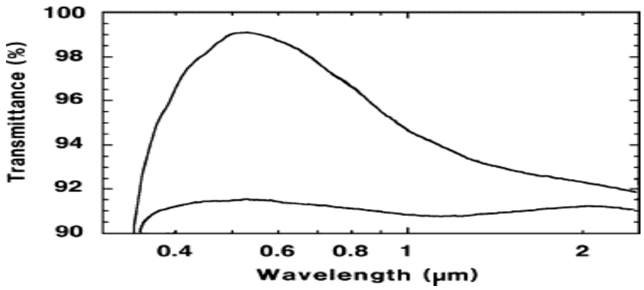



Fig. 7. Spectral transmittance of a glass plate coated on both sides by anti reflecting thin films of porous silica. (11)

**Solar photo voltaics**:

The term "photovoltaic" comes from the Greek φῶς (*phōs*) meaning "light", and from "Volt", the unit of electromotive force, the volt, which in turn comes from the last name of the Italian physicist Alessandro Volta, inventor of the battery (electrochemical cell). The term "photo-voltaic" has been in use in English since 1849.[12]

Photovoltaicsis the field of technology and research related to the practical application of photovoltaic cells in producing electricity from light, though it is often used specifically to refer to the generation of electricity from sunlight. Cells can be described as *photovoltaic* even when the light source is not necessarily sunlight (lamplight, artificial light, etc.). In such cases the cell is sometimes used as a photodetector (for example infrared detectors), detecting light or other electromagnetic radiation near the visible range, or measuring light intensity[13].

Fig8: solar cell made from a monocrystalline silicon wafer.

Fig 9: Solar cells can be used to build a small solar collection devices such as this portable monocrystalline solar charger.

The operation of a photovoltaic (PV) cell requires 3 basic attributes: I.
II.
1. The absorption of light, generating either electron-hole pairs or excitons. III.
2. The separation of charge carriers of opposite types.
3. The separate extraction of those carriers to an external circuit.

In contrast, a solar thermal collector collects heat by absorbing sunlight, for the purpose of either direct heating or indirect electrical power generation. "Photo electrolytic cell" (photoelectron chemical cell), on the other hand, refers either a type of photovoltaic cell (like that developed by A.E. Becquerel and modern dye-sensitized solar cells) or a device that splits water directly into hydrogen and oxygen using only solar illumination.

Various materials display varying efficiencies and have varying costs. Materials for efficient solar cells must have characteristics matched to the spectrum of available light. Some cells are designed to efficiently convert wavelengths of solar light that reach the Earth surface. However, some solar cells are optimized for light absorption beyond Earth's atmosphere as well. Light absorbing materials can often be used in *multiple physicalconfigurations* to take advantage of different light absorption and charge separation mechanisms.Materials presently used for photovoltaic solar cells include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium selenide/sulfide. Many currently available solar cells are made from bulk materials that are cut into wafers between 180 to 240 micrometers thick that are then processed like other semiconductors.

Other materials are made as thin-films layers, organic dyes, and organic polymers that are deposited on supporting substrates. A third group are made from nanocrystals and used as quantum dots (electron-confined nanoparticles). Silicon remains the only material that is well-researched in both *bulk* and *thin-film* forms.

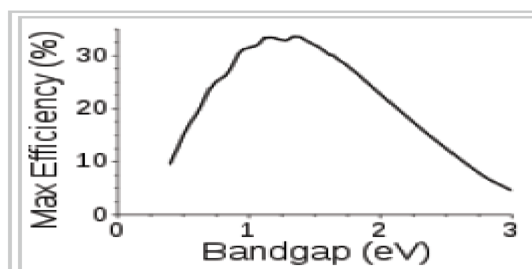



Fig 10 : The Shockley- Quesser limit for the theoretical maximum efficiency of a solar cell. Semiconductors with band gap between 1 and 1.5 eV, or near infrared light, have the greatest potential to form an efficient cell [14]

**Crystalline Silicon**:

By far, the most prevalent *bulk* material for solar cells is crystalline silicon (abbreviated as a group as *c-Si*), also known as "solar grade silicon". Bulk silicon is separated into multiple categories according to crystallinity and crystalsize in the resulting ingot, ribbon, or wafer.

**Monocrystalline Silicon(c-Si):**

Often made using the Czochralski process. Single-crystal wafer cells tend to be expensive, and because they are cut from cylindrical ingots, do not completely cover a square solar cell module without a substantial waste of refined silicon. Hence most *c-Si* panels have uncovered gaps at the four corners of the cells.

**Polycrystalline silicon, or multicrystalline silicon, (poly-Si or mc-Si):**

Made from cast square ingots — large blocks of molten silicon carefully cooled and solidified. Poly-Si cells are less expensive to produce than single crystal silicon cells, but are less efficient. United States Department of Energy data show that there were a higher number of polycrystalline sales than monocrystalline silicon sales.

**Ribbon silicon[15] is a type of polycrystalline silicon:**

It is formed by drawing flat thin films from molten silicon and results in a polycrystalline structure. These cells have lower efficiencies than poly-Si, but save on production costs due to a great reduction in silicon waste, as this approach does not require sawing from ingots.

Mono-like-multi silicon: Developed in the 2000s and introduced commercially around 2009, monolike- multi, or cast-mono, uses existing polycrystalline casting chambers with small "seeds" of mono material. The result is a bulk mono-like material with poly around the outsides. When sawn apart for processing, the inner sections are high-efficiency mono-like cells (but square instead of "clipped"), while the outer edges are sold off as conventional poly. The result is line that produces mono-like cells at poly-like prices.[16]

Analysts have predicted that prices of polycrystalline silicon will drop as companies build additional polysilicon capacity quicker than the industry's projected demand. On the other hand, the cost of producing upgraded metallurgical-grade silicon, also known as UMG Si, can potentially be one-sixth that of making poly silicon.[17]

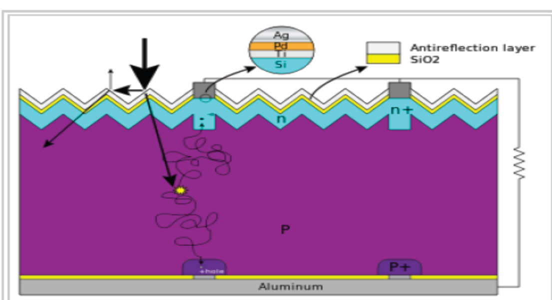



Fig 11: Basic structure of a silicon based solar cell and its working mechanism[18]

**Thin films:**

Thin-film technologies reduce the amount of material required in creating the active material of solar cell. Most thin film solar cells are sandwiched between two panes of glass to make a module. Since silicon solar panels only use one pane of glass, thin film panels are approximately twice as heavy as crystalline silicon panels. The majority of film panels have significantly lower conversion efficiencies, lagging silicon by two to three percentage points.[19] Thin film solar technologies have enjoyed large investment due to the success of First Solar and the largely unfulfilled promise of lower cost and flexibility compared to wafer silicon cells, but they have not become mainstream solar products due to their lower efficiency and corresponding larger area consumption per watt production. Cadmium telluride (CdTe), copper indium gallium selenide (CIGS) and amorphous silicon (A-Si) are three thin-film technologies often used as outdoor photovoltaic solar power production. CdTe technology is most cost competitive among them. CdTe technology costs about 30% less than CIGS technology and 40% less than A-Si technology in 2011.

Cadmium telluride solar cell uses a cadmium telluride (CdTe) thin film, a semiconductor layer to absorb and convert sunlight into electricity. The cadmium present in the cells would be toxic if released. However, release is impossible during normal operation of the cells and is unlikely during fires in residential roofs.[13] A square meter of CdTe contains approximately the same amount of Cd as a single C cell Nickel-cadmium battery, in a more stable and less soluble form.[20]

Solar PV modules are solid-state semiconductor devices that convert sunlight into direct-current electricity. Materials used on PV panels are mono-crystalline silicon, polycrystalline silicon, micro- crystalline silicon, copper indium selenide, and cadmium telluride [21].

Because of the varying solar intensity throughout the day the Photovoltaic panels becomes inefficient in capturing the energy which is delivered from the Sun planet. These CSP systems are highly efficient in capturing maximum sun energy compared to PV panels. In CSP systems especially in power tower receivers use molten salt as a heat transfer medium to generate steam through heat exchangers.

3. **Application of nano- fluids for solar collector, solar ponds, solar cells and solar stills**:
4.
5. Common fluids such as water, ethyle glycal and heat transfer oil play an important role in power generation and industrial processes but these fluids are having relatively loe thermal conductivity, so to overcome this barrier we have to use ultra fine solid particles suspended in common fluids. The suspension of nano sized particles in a conventional based fluid is called a nanofluid. If we use a mixture of water and aluminium nanoparticles as a working fluid in a direct absorption solar collector, the efficiency increases remarkably from 0.1% to 5 % for low values of volume fraction of nano particles.(22). Otanicar et al. (23) investigated both experimentally and numerically the effects of different nanofluids are carbon nanotubes, graphite and silver on the performance of a micro scale direct absorption solar collector(DASC).

Salinity gradient ponds are great bodies of water between 2 -5 m deep, which could collect solar radiation and store in the form of heat. When a nanofluid flows through a heat exchanger mounted at the bottom of the solar pond to absorb the heat. It expects that nanofluids could enhance the rate of heat removal from the bottom of the solar pond.

Cooling of solar cells can inprove the efficiency of solar cells such as Aluminium oxide and water as a nanofluid

Due to lack of getting pure drinking water the world wide population is getting water borne diseases. At present in Hyderabd (India) people are facing safe drinking water problem and also provision of fresh water is more critical because of greenhouse gas emissions(GGE) is one of the factor. In these regions, solar desalination systems can solve part of the problem where solar energy is available plenty. Solar stills can be used to avoid GGE by adding carbon nanotubes (CNTs) to the water inside a single basin solar still. Results shown that 50 % of the efficiency was increased (24).

**Future scope**:

So far materials are used for solar cells, solar panels for International space station, space launch vehicles, solar stills and solar ponds. These materials can also be used for Aero plane wings for storing the solar energy and wings can be made as solar cells and can be used this power for refrigeration system of aircraft, for electrical supply of air craft interior and for exterior uses.

**Conclusion**:

India has a severe electricity shortage. It needs massive additions in capacity to meet the demand of its rapidly growing economy. Development of solar energy, which is indigenous and distributed and has low marginal cost of generation, can increase energy security by diversifying supply, reducing import dependence, and mitigating fuel price volatility. Solar energy development in India can also be an important tool for spurring regional economic development, particularly for many underdeveloped states, which have the greatest potential for developing solar power systems which is unlimited and clean source of energy. It can provide secure electricity supply to foster domestic industrial development. This paper reviews the application of different materials in renewable energy source. Especially nanofluids are advanced fluids and are used for improving the performance of solar collectors, solar ponds, solar stills and for cooling the solar cells. Significant improvements have already been accomplished governmental and non-governmental levels of organizations. This should be continued and should be available renewable energy to the remote areas of the world. So it can be concluded that photovoltaic power systems will have an important share in the electricity of the future not only in India, but all over world.

## References


1. USDepartmentofEnergy.Internationalenergyoutlook2009.Technical report DOE/EIA-0484;USDepartmentofEnergy;2009http://www.eia.doe.gov/oiaf/ieo/pdf/0484(2009).pdf.
2. Khatib H. Renewable energy in developing countries. In: Proceedings of the international conference on renewable energy—clean power, London, UK; 1993. p.1–6.
3. XiaX, Xia J.Evaluation of potential for developing renewable sources of energy to facilitate development in developing countries. In: Proceedings of the Asia-Pacific power and energy engineering conference, Chengdu,China; 2010. p.1–3.
4. US Energy Information Administration. World map of solar resources;2011 /http://www.eia.gov/energyexplained/index.cfm?page=solar_whereS.
5. Solarupdrafttower;2010 /http://www.renewable-energy-info.com/solar/ updraft-tower.htmlS.
6. Razykov T, Ferekides C,Morel D,Stefanakos E, UllalH, Upadhyaya H. Solar photovoltaic electricity :current status and future prospects. SolarEnergy 2011;85(8):1580–608.
7. KroppR.Solarexpectedtomaintainitsstatusastheworld'sfastest-growing energy technology /http://www.socialfunds.com/news/article.cgi/2639.html S; 2009.
8. Jacobson M. Review of solutions to global warming, air pollution, and energy security. Technicalreport.Stanford;2008.
9. REN21.Renewables2011,global status report.Technical report;REN21;2011.
10. Swanson R. Photo voltaic power up. Science Magazine2009;324: 891–2.
11. Hirshman W.Surprise, surprise cell production2009:survey.PhotonInter- national 2010:176–99.
12. Wikipedia.SuntechPower;2012 /http://en.wikipedia.org/wiki/Suntech_PowerS.
13. Wikipedia.JASolarHoldings;2012 /http://en.wikipedia.org/wiki/JA_SolarS.
14. Wikipedia.FirstSolar;2012 /http://en.wikipedia.org/wiki/First_SolarS.
15. Wikipedia.YingliGreenEnergyHoldingCompanyLimited;2012/http://en.wikipedia.org/wiki/Yingli_SolarS.
16. *Basic Research Needs for Solar Energy Utilization*,Lewis NS and Crabtree G. (Eds.) Office of Science:U.S. Department of Energy, 2005.
17. *Organic Photovoltaics: Mechanisms, Materials, and Devices*, Sun S-S and Sariciftci NS. (Eds.) Taylor & Francis: Boca Raton, FL, 2005.
18. Nelson J. In *The Physics of Solar Cells*, Imperial College Press: 2002; pp 17–39.
19. Wikipedia. Solar cell ;2013 /http://en.wikipedia.org/wiki/Solar cell.
20. Yanadori, H. and Masuda, T., Solar Energy, 1989, 42(l), 27.
21. <http://www.socialfunds.com/news/article.cgi/2639.html >
22. H. Tyagi, P.Phelan , R. Prashar, Predicted efficiency of a low temperature nanofluid- based direct absorption solar collector. J. solar energy Eng 131(2009)041004.
23. T.P.Otanicar, P. Phelan, R,S. Prashar, G.Rosengarten, R.A. Taylor , Nanofluid based direct absorption solar collector , J. Renew.sustain, energy 2 (2010)033102.
24. S. Nijmeh, S.Odeh, Experimental and theoretical study of a single basin solar still in Jordan, J. Heat and Mass transfer 32 (2005) 565-572.