International Research Journal of Natural and Applied Sciences
Vol. 3, Issue 10, October 2016 IF- 3.827 ISSN: (2349-4077)
© Associated Asia Research Foundation (AARF)
Website: www.aarf.asia Email : editor@aarf.asia , editoraarf@gmail.com

CONVERSION OF SUNLIGHT INTO ELECTRICITY – AN ELECTRICITY DEVICE SOLAR CELL

Anil Kumar Das
Asst. Prof., Physics Deptt. ,
St. John's College, Agra

ABSTRACT

The purpose of this case study to understand the concept of solar energy. How sunlight energy in converted into electricity using solar energy concept?

Solar energy obtained from the sun. Solar cell is the cell which is the conversion of solar energy into electrical energy. It is an electrical device by using photovoltaic effect (physical and chemical phenomenon). Solar cell is also known as photovoltaic cell. Photovoltaic cell uses the energy of light (source of light can be sunlight or an artificial light) to convert directly into electricity.

Various advantages it can bring to customer and environment are; it is clean and non-polluting source of energy, it is a renewable energy source, solar cells do not produce noise and they are totally silent, require very little maintenance, are long lasting sources of energy which can be used almost anywhere, have long life time and are no fuel costs or fuel supply problems.

OBJECTIVES

- Understand the concept of Sunlight and Solar energy
- How we can convert solar energy into electricity?
- Advantage of solar energy in today's scenario
- The solar cell is to develop solar power device without sun and of low cost.

KEYWORDS

- Solar cells
- Solar Energy
- Sunlight
- Photo electrochemical cell
- Electricity
- Solar-tech

INTRODUCTION

Brief on Solar Energy

Solar energy: an energy obtained from the sun (i.e., sunlight). Solar cell is the cell which is the conversion of solar energy into electrical energy. It is an electrical device by using photovoltaic effect (physical and chemical phenomenon).Solar cell is also known as photovoltaic cell. Photovoltaic cell uses the energy of light (source of light can be sunlight or an artificial light) to convert directly into electricity.

Individual solar cell devices can be combined to form modules, otherwise known as solar panels.

Characteristics of this device are resistance, current or voltage. A single junction silicon solar cell can produce a maximum open-circuit voltage of approximately 0.5 to 0.6 volts. Photodetectors are those which detects light or measuring light intensity. They are used as photodetectors which measures light intensity or electromagnetic radiation in the visible range.

Invented by

In 1839, at age 19, he built the world's first photovoltaic cell in his father's laboratory. Willoughby Smith first described the "Effect of Light on Selenium during the passage of an Electric Current" in a 20 February 1873 issue of Nature. In 1883 Charles Fritts built the first solid state photovoltaic cell by coating the semiconductor selenium with a thin layer of gold to form the junctions; the device was only around 1% efficient.

In 1888 Russian physicist Aleksandr Stoletov built the first cell based on the outer photoelectric effect discovered by Heinrich Hertz in 1887.

In 1905 Albert Einstein proposed a new quantum theory of light and explained the photoelectric effect in a landmark paper, for which he received the Nobel Prize in Physics in 1921. Vadim Lashkaryov discovered p-n-junctions in silver sulphide protocells in 1941. Russell Ohl patented the modern junction semiconductor solar cell in 1946 while working on the series of advances that would lead to the transistor. The first practical photovoltaic cell was publicly demonstrated on 25 April 1954 at Bell Laboratories. The inventors were Calvin Souther Fuller, Daryl Chapin and Gerald Pearson. Solar cells gained prominence with their incorporation onto the 1958 Vanguard I satellite.

The basic 3 attributes of a photovoltaic (PV) cell or solar cell are:

1. Absorption of light, generating electron hole pairs (excitons)
2. Separation of charge carries of opposite types.
3. Separate extraction of those which carriers to an external circuit.

A photoelectrochemical cell is of type photovoltaic cell that splits water directly into hydrogen and oxygen. But a solar thermal collector supplies heat by absorbing sunlight in contrast.Solar thermal either direct heat or generate indirect electrical power from heat.

Photodetectors and photovoltaic cells are devices that convert an optical input into current. A solar cell is same as photovoltaic device, i.e., a device which generates voltage when exposed to light. The photovoltaic effect was discovered by Alexander-Edmond Becquerel in 1839, in a junction formed between an electrode (platinum) and an electrolyte (silver chloride). In a semiconductor due to the absorption of light radiation, it generates the voltage across the PN junction that is called photovoltaic effect. Photodetector functionality is same as solar cell. It's a photodiode which is unbiased and load is connected to it.

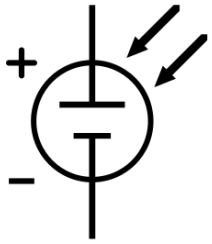
There are three differences between a solar cell and photodetector:

1. A photodiode works on a narrow range of wavelength but a solar cell need to work over a broad spectral range (solar spectrum).
2. Solar cells are wide area devices which maximizes exposure.
3. Photodiodes are quantum efficiency, which defines the signal to noise ratio, while solar cells are power conversion efficiency, which is the power delivered per incident

solar energy. Usually solar cells are designed to maximize the delivered power by using the external load.

STUDY / WORKING OF SOLAR ENERGY

Symbol of a photovoltaic cell



Working of photovoltaic cell

When a solar panel exposed to sunlight, the light energies are absorbed by a semiconduction materials. Due to this absorbed energy, the electrons are liberated and produce the external DC current. The DC current is converted into 240-volt AC current using an inverter for different applications. Thus, when this p and n layers are connected to external circuit, electrons flow from n-layer to p-layer, hence current is generated. The electrons that leave the solar cell as current give up their energy to whatever is connected to the solar cell, and then re-enter the solar cell. Once back in the solar cell, the process begins again.

Converting Sunlight Into Electricity / How Does Solar Work?

For the billions of years plants have been living off of solar energy. The technology has evolved making the solar energy looks very simple as plug into the sun. The development over the decades has been refined for the machinery used behind this magic. This is no longer experimental technology but a mature, reliable source of energy production.

Solar panels are the machinery used to plugging into the sun by absorbing solar energy with photovoltaic (PV) cells. They generate electricity when hit with sunlight, which then flows into a device called an inverter which converts the electricity into a form (120 volts, 60Hz) for household use. Whenever you plug into the wall, the solar electricity will behave same as utility electricity.

If there is no Sun then?No sun. No Problem. On cloudy days when there is no sunlight not enough solar energy gets generated, or in nights when there is no sun nothing gets generated, you will still be connected to the electric grid from which you can draw energy. In this way the electric grid is like a battery, always holding energy at the ready to supply power when needed.

A conventional crystalline siliconsolar cell. Electrical contacts made from busbars (the larger silver-colored strips) and fingers (the smaller ones) are printed on the carbon wafer.

Solar cellconsists of a n-type semiconductorlayer and p-type semiconductor layer. The two layers are combinedto forms p-n junction. Anti-reflection coating is used to avoid the loss of incident light energy due to reflection atthe surface.

Types of solar cellbased on the types of crystal used

1. Mono crystalline silicon cells - The Mono crystalline silicon cell is produced from pure silicon (single crystal). Since the Mono crystalline silicon is pure and defect free, the efficiency of cell will be higher.
2. Polycrystalline silicon cells - In Polycrystalline solar cell, liquid silicon is used as raw material and polycrystalline silicon was obtained followed by solidification process. The materials contain various crystalline sizes. Hence, the efficiency of this type of cell is less than Mono crystalline cell.
3. Amorphous silicon cells - Amorphous silicon was obtained by depositing silicon film on the substrate like glass plate. The layer thickness amounts to less than 1µm – the thickness of a human hair for comparison is 50-100 µm.

Comparison between types of solar cell Material Efficiency (in %) Mono crystalline silicon 14-17 Polycrystalline silicon 13-15 Amorphous silicon 5-7.

Advantages of Solar cells

- It is clean and non-polluting.
- It is a renewable energy.
- Solar cells do not produce noise and they are totally silent.
- They require very little maintenance.
- They are long lasting sources of energy which can be used almost anywhere.
- They have long life time.
- There are no fuel costs or fuel supply problems.

Disadvantages of Solar cells

- Solar power can`t be obtained in night time.
- Solar cells (or) solar panels are very expensive.
- Energy has not be stored in batteries.
- Air pollution and whether can affect the production of electricity.
- They need large area of land to produce more efficient power supply.

Uses of Solar cells

- long lasting sources of energy, low maintenance
- silent and non-polluting sources of electricity
- provides cost-effective power supplies for people remote from the main electricity grid
- flexible and convenient source of small amount of power
- in powering space vehicles like satellites and telescope
- to power automotive, lights, pools, heaters and gadgets

A new use of photovoltaic energy- solar powered transportation

Railway roads, subways, planes, cars, buses and even roads are powered by solar. Solar cars are uses in racing around the world especially in Australia. Solar buses reducing its carbon

footprints in china;and simultaneously maintaining efficient mass transit in highly populated cities like Beijing.

Wearable Solar-tech

An Anker's power port can charge any cell phone, e-reader or a tablet. Some solar powered flashlights are invented which can be charged when exposed to sunlight. Music speakers, solar air-conditioner, thermostats, solar dryers, solar visor radios, freezers/ mini-fridges are some examples of solar tech.

Latest Inventions

DIY Solar Panels Become Popular in 2005 as the technology and efficiency of solar cells have increased. Solar panels can be made by putting together a solar panel kit to planning a solar array.

Solar cells as thin as paper can now be manufactured using an industrial printer. They have 20% power conversion efficiency, and a single strip can produce up to 50 watts per square meter. This is great news for the 1.3 billion people in developing countries, as the strips are flexible and inexpensive to produce. Flexible Printed Solar Panels Hit the Market in 2015.

A research team from the University of California, Berkeley, and the Australian National University discovered new properties of nanomaterial. One of these properties is called magnetic hyperbolic dispersion, which means the material glows when heated. If combined with thermophotovoltaic cells, it could turn heat into electricity without the need for sunlight. The Sunless Solar Power is discovered in 2016.

Recent inventions gave birth to a solar thermal fuel in the form of a transparent film that can be applied to a car windshields in which the windshield can melt ice at night using energy absorbed during the day.

To create fuel directly from sunlight, another way which has been developed by researchers at the University of Illinois at Chicago. To convert atmospheric carbon dioxide into "syngas," they use "artificial leaves" for sunlight. Syngas is a mixture of hydrogen gas and carbon monoxide. It can be burned directly or converted into more conventional fuels. This process removes CO2 from the atmosphere its an advantage.

PV cell using carbon nanotubes and fullerenes rather than silicon a prototype has been created by a team at Stanford. It only uses carbon as a raw material, so its efficiency is far below that of ordinary or commercially available silicon solar cells. in conventional solar

cells, the Stanford prototype does not contain toxic materials that form part of the electrodes. So, it's a more environmental friendly alternative to silicon.

CONCLUSION

Solar power is good source of useable energy and it can be converted into another energy source. We receive solar energy from Sun. Energy light shifts electron into other materials. This effect is able to generate large scale electricity. At present low efficiency of solar cells required to large demand to supply electricity. Direct use of solar energy is renewable. It means it is capable of ultimately replacing global energy supply from non-renewable sources. Advantages it will bring to environment is; it will not create pollution, cheap source of energy, can provide output for large customers and there are various other advantages. So we should work on installation of this energy even at our home.

REFERENCES

Goswami, D. Yogi, Frank Kreith, and Jan F. Kreider. *Principles of solar engineering.* 2nd ed. Philadelphia, Taylor & Francis, c2000.694 p. Includes bibliographical references.

Kryza, Frank. T. *The power of light: the epic story of man's quest to harness the sun.* New York, London, McGraw-Hill, c2003.298 p.

Laird, Frank N. *Solar energy, technology policy, and institutional values.* Cambridge, Eng., New York,Cambridge University Press, 2001.248 p.

Perlin, John. *From space to earth: the story of solar electricity*. Cambridge, MA, Harvard University Press, 2002.221 p.

Scheer, Hermann. *The solar economy: renewable energy for a sustainable global future.* London, Sterling, VA, Earthscan, 2002.

Sklar, Scott, and Kenneth G. Sheinkopf. *Consumer guide to solar energy: new ways to lower utility costs, cut taxes, and take control of your energy needs.* 3rd ed. Chicago, Bonus Books, c2002.195 p.

History and overview of solar heat technologies. Edited by Donald A. Beattie. Cambridge, MA, MIT Press, c1997. 278 p.

Porteous, Colin, and Kerr MacGregor. *Solar architecture in cool climates.* London, Sterling, VA, Earthscan, 2005.266 p.

Tiwari, G. N. *Solar energy: fundamentals, design, modelling and applications.* New York, Nova Science Publishers, c2006. 525 p.

Clean electricity from photovoltaics. Edited by Mary D. Archer and Robert Hill.London, Imperial College Press, c2001.844 p.

Goetzberger, A., and V. U. Hoffmann. *Photovoltaic solar energy generation.* Berlin, New York, Springer,2005.232 p.

Green, Martin A. *Third generation photovoltaics: advanced solar energy conversion.* Berlin, New York, Springer, c2006.160 p.

Messenger, Roger A., and Jerry Ventre. *Photovoltaic systems engineering.* 2nd ed. Boca Raton, FL, CRC Press, c2004. 455p.

Nelson, Jenny. *The physics of solar cells.* London, Imperial College Press; River Edge, NJ, Distributed by World Scientific Pub.Co., c2003.363 p.

Next generation photovoltaics: high efficiency through full spectrum utilization. Edited by Antonio Martí and Antonio Duque.Bristol, Eng., Philadelphia, Institute of Physics, c2004.332 p.

Organic photovoltaics: mechanism, materials, and devices. Edited by Sam-Shajing Sun, NiyaziSerdarSariciftci.Boca Raton, FL, Taylor & Francis, 2005.629 p.

Photovoltaics and architecture: an introduction for architects and engineers. Edited by Randall Thomas. New York, Spon Press, 2001. 155 p.

Gurley, Virginia Heather. *Solar cooking naturally.* 4th ed. Sedona, AZ, SunLightWorks, 1999.92 p.

Leutz, Ralf, and Akio Suzuki. *Nonimaging Fresnel lenses: design and performance of solar concentrators.* Berlin, New York, Springer, c2001. 272 p. (Springer series in optical sciences, v. 83)

Hermannsdörfer, Ingrid, and Christine Rüb. *Solar design: photovoltaics for old buildings, urban space, landscape. Photovoltaik für Altbau, Stadtraum, Landschaft.* Berlin, Jovis, c2005. 143

Patel, Mukund R. *Wind and solar power systems: design, analysis, and operation.* 2nd ed. Boca Raton, FL, Taylor & Francis, c2006.448 p.

Blanco Gálvez, Julián, and SixtoMalato Rodríguez. *Solar detoxification*. Paris, UNESCO Pub., 2003. 187 p.

Solar energy in agriculture. Edited by Blaine F. Parker. Amsterdam, New York, Elsevier, distributor for the United States and Canada, c1991.447 p.

Thacher, Eric Forsta. *A solar car primer.* New York, Nova Science Publishers, c2003. 1 v.

"Solar." EIA Energy Kids -.U.S. Energy Information Administration, n.d. Web. 12 May 2014.

"HowStuffWorks "How Can Solar Panels Power a Car?"" HowStuffWorks.© 1998-2014 HowStuffWorks, Inc, n.d. Web. 13 May 2014.

"Solar Thermal."EIA Energy Kids -.U.S. Energy Information Administration, n.d. Web. 13 May 2014

Parks, Peggy J. Solar Power. San Diego, CA: ReferencePoint, 2010. Print.

Thomas, Isabel. The Pros and Cons of Solar Power. New York: Rosen Central, 2008. Print.

Morris, Neil. Solar Power. North Mankato, MN: Smart Apple Media, 2007. Print.

"Amazon Prime Free Trial." Solar Energy (Innovative Technologies): Christine Zuchora-Walske, Michael McGehee: 9781617834677: Amazon.com: Books. N.p., n.d. Web. 14 May 2014.

Zuchora-Walske, Christine. Solar Energy. Minneapolis, MN: ABDO Pub., 2013. Print.

Toothman, Jessika, and Scott Aldous. "How Solar Cells Work." HowStuffWorks. HowStuffWorks.com, 01 Apr. 2000. Web. 14 May 2014.

"Solar Electricity." Solar Energy:.National Renewable Energy Laboratory and the Department of Energy., n.d. Web. 14 May 2014.

Advantages and Disadvantages of Solar Power, Facts about Solar Power."Advantages and Disadvantages of Solar Power, Facts about Solar Power.University of Minnesota, n.d. Web. 15 May 2014.

Reynoldson, Fiona. Understanding Solar Power. New York: Gareth Stevens Pub., 2011. Print.

"Top 10 Countries Using Solar Power." One Block Off the Grid Top 10 Countries Using Solar Power Comments. Copyright 2012, One Block Off the Grid a Pure Energies Group Company, n.d. Web. 15 May 2014.

Schlager, Neil, and Jayne Weisblatt. Alternative Energy. Detroit: UXL, 2006. Print.

"Uses of Solar Energy | Solarbuzz."Uses of Solar Energy | Solarbuzz. NPD Solarbuzz.,n.d. Web. 15

"Who Discovered Solar Energy?" Who Discovered Solar Energy? Yukozimo, n.d. Web. 15 May 2014.

"Top 6 Things You Didn't Know About Solar Energy." Energy.gov. 1000 Independence Ave. SW Washington DC 20585 202-586-5000, n.d. Web. 15 May 2014.

Kirschbaum, Erik. "Germany Sets New Solar Power Record, Institute Says."Reuters. Thomson Reuters, 26 May 2012. Web. 20 May 2014.

"SkyFuel's Parabolic Troughs Are 73% Efficient." Renewable Energy World. RenewableEnergyWorld.com. Web. 21 May 2014.

"Concentrated Solar Power."Concentrated Solar Power.Web. 20 May 2014.

Solar Panel and Batteries with Sun Symbol for Alternative Energy Concept.Digital image.ICLIPART.N.p., n.d. Web. 22 May 2014.

An Installation of Solar Panels in Rural Mongolia.Digital image.Http://en.wikipedia.org/.N.p., n.d. Web. 22 May 2014.

Sulucarps10. Digital image. Afloresm. N.p., 23 Sept. 2007. Web. 23 May 2014.

Sandia Labs.Sandias Solar Research. Digital image. N.p., 23 Oct. 2014. Web. 23 May 2014.

Collette, Denis. Sun Rays Dancing.Digital image.Flickr.N.p., n.d. Web.

Ray, MIke. Solar Energy. Digital image. Flickr. N.p., n.d. Web.

Henry, Junior. Energy Blues.Digital image.Flickr.N.p., 29 Sept. 2011. Web. 23 May 2014.