The Empirical Modeling and investigation of Solar Panel tilt angle analysis

Osahenvemwen, O.A.[1], Ebhomien, J.E.[2] and Oshodin, O.D.[3]

[1]Electrical and Electronic Department, Faculty of Engineering and Technology, Ambrose Alli University,Ekpoma,Nigeria.
[2]Electrical and Electronic Department, School of Engineering, National Institute of construction Technology, Uromi
[3]Computer Engineering Department, Faculty of Engineering, University of Benin

Abstract

This study presents the Empirical modeling and investigation of Solar Panel tilt angle analysis, to determine the best suitable tilt angle used to obtain optimal or maximum voltage from the solar panel system. Moncrystalline solar panel with 220 W was used to determine the output voltage from the solar panel, along with range of angles measured in degree from 180^0 to 90^0 and with responding time in hours from 11:00 am to 5.00 pm toward both east and west hemisphere direction. The experiment was carried out for duration of one year at Ambrose Alli University, Ekpoma. Situated at longitude 6^0 $10^{'}$ to 60^0 40' and latitude 60^0 $10^{'}$ to 60^0 $40^{'}$. The results obtained are average output voltage with respect to time and angles presented graphically, for both east and west hemisphere direction. Also the total output voltage (2745.32Volt) obtained from west hemisphere direction was higher than the east hemisphere direction voltage (2709.06Volts). The best tlit angle suitable for optimal voltage output is 10^0 degree. Based on the modeling, it is observed that the output voltage in a day at constant angle exhibits a logarithmic distribution pattern and it possesses the least error or R^2 value of 0.019.

Keywords: Logarithmic distribution, Solar panel, Sunlight, Tilt angle, Voltage

1. INTRODUCTION

Sun, is created by GOD, this sun has the ability to support life on earth by providing source of energy to living things on earth. The existence of nearly all the living thing both, autotrophs and heterotrophs are supported by sunlight from the sun. The autotrophs such as plants, uses the energy of the sunlight, combined it with carbon dioxide and water to produce simple sugar, this process is known as photosynthesis. While heterotrophs, such as animals, uses sunlight indirectly by consuming the products of autotrophs, either by consuming autotrophs, or by consuming their products or by consuming other heterotrotrophs (Kreith,2012 and Theraja ,2004).The environment has been polluted due to human activities and quest for development. The byproducts deduce from industrial pollution are hazardous to mankind. Therefore effort should made to respective agent to encourage research are environment friendly. In this light the solar power system is considered in this research due to non pollution of the environment. The major component of solar power system is the solar panel, which is used to generate light from the sunlight radiation from the Sun (Evbogbai et al, 2009). Sunlight, in the broad sense, is the total frequency spectrum of electromagnetic radiation given off by the sun, particularly infrared, visible and ultraviolet light. On Earth, sunlight is filtered through the earth atmosphere, and is obvious as daylight when the Sun is above the horizon. When the direct solar radiation is not blocked by clouds, it is experienced as sunshine, a combination of bright light and radiant heat. When it is blocked by the clouds or reflects off of other objects, it is experienced as diffused light or night (http://en.Wikipedia.org/wiki/solar-energy,2013). The world meteorological organization uses the term "sunshine duration" to mean the cumulative time during which an area receives direct irradiance from the Sun of at least 120watts per square meter Sunlight may be recorded using a sunshine recorder, Pyranometer or Pyrheliometer (http://en.Wikipedia.org/wiki/solar-energy, 2013; Theraja and Theraja, 2004). Sunlight takes about 8.3 minutes to reach the Earth. On average, it takes energy between 10,000 and 170,000 years to leave the sun's interior and then be emitted from the surface as light. Direct sunlight has a luminous efficacy of about 93lumens per watt of radiant flux. Bright sunlight provides illuminance of approximately 100,000 lux or lumens per square meter at the Earth's surface (Rizk and Nagarial, 2009).

The Bases for the Change in Sun Energy

The amount of heat energy received at any location on the globe is a direct effect of sun angle on climate, as the angle at which sunlight strikes the Earth varies by location, time of day, and season due to the Earth orbit around the sun and the Earth's rotation around its tilted axis. Seasonal change in the angle of sunlight, caused by the tilt of the Earth's axis, is the basic mechanism that results in warmer weather in summer than in winter. Change in day length is another factor (http://ec.europa.en/energy/publications/doc/2009_report-solar-energy.pdf, 2013 and http//:www.pa.msu.edu/~duxbury/cnd/solar efficiency.pdf, 2013).

The Risks and Benefits of Sun Exposure to Human Body

The advantages and disadvantage of sun to human body are as follows;

1. Skin tanning is achieved by an increase in the dark pigment inside skin cells called Melanocytes and it is actually an automatic response mechanism of the body to sufficient exposure to ultraviolet radiation from the sun or from artificial sunlamps. Thus, the tan gradually disappears with time, when one is no longer exposed to these sources.

2. Sunburn can have mild to severe inflammation effects on skin; this can be avoided by using a proper sunscreen cream or lotion or by gradually building up Melanocytes with increasing exposure.
3. Also people suffering from Psorisasis, while sunbathing is an effective way of healing the symptoms.
4. The risks and benefits of sun exposure to human body are as follows, The body receives vitamin D from sunlight (specifically from the UVB band of ultraviolet light), and excessive seclusion from the sun can lead to deficiency unless adequate amounts are obtained through diet.
5. Another detrimental effect of ultraviolet light exposure is accelerated skin aging (also called skin Photodamage) which produces a difficult to treat cosmetic effect. While people are concerned that ozone depletion is increasing the incidence of such health hazards. A 10% decrease in ozone layer, could cause a 25% increase in skin cancer.
6. A lack of sunlight, on the other hand, is considered one of the primary causes of Seasonal Affective Disorder (SAD), a serious form of the "winter blues". SAD occurrence is more prevalent in locations further from the tropics, and most of the treatments (other than prescription drugs) involve light therapy, replicating sunlight via lamps tuned to specific wavelengths of visible light, or full-spectrum bulbs.
7. A recent study indicates that more exposure to sunshine early in a person's life relates to less risk from Multiple Sclerosis (MS) later in life ("Solar energy, available at http://en. Wikipedia.org/wiki/solar-energy 2014, Dobrzanski, 2009, Enda, 2011, Pijush,2010 and http:iiitb.biz/srao/paper/solar/2011)

Recent time, researchers have stress the important of obtaining maximum voltage output from solar panel, based on tilt angle placement by Felix and Emmanuel, 2013, Fawaz et al, 2012 etc. But similar research has not been carried out in this location under investigation. Also, despite various tilt angle models but the distribution pattern of voltage has not been determined. Therefore this study is directed toward these areas.

2. METHODOLOGY

The Empirical modeling and investigation of Solar Panel tilt angles analysis is carry out at Ambrose Alli University, Ekpoma. Situated at longitude 6^0 10' to 60^0 40' and latitude 60 10' to 60^0 40', within a period of one year. This study is on empirical modeling and investigation of Solar Panel tilt angles using moncrystalline solar panel, with 220 Watt, Maximum Power Voltage (Vmp) 33.1V, Maximum Power Current (Imp) 6.54A, Open Circuit Voltage(Voc) 41.8V Short Circuit Current (Isc) 7.92A, Power tolerance(%) +5%, and Maximum System Voltage (V) of 1000V DC. Also, the addition equipments used was precision level, protractor, voltmeters etc. The corresponding voltages were obtained from various angles (degree) and intensity of sunlight at various times (hours). Also, the obtained voltage values were simulated using excel program to obtain a model. A swims table was constructed and attached with protractor to measure the angle. Also, voltmeter was connected to solar panel used to measure the voltage with corresponding angles in degree presented in Figure 1.

Fig 1 Voltage Measurement from the position of Solar Panel tilting process

3. Result and Discussion

In Fig 2 present the corresponding voltages obtained in volts with various angles in degree and different time in hours. These corresponding voltages were obtained from solar panel output from west direction hemisphere.

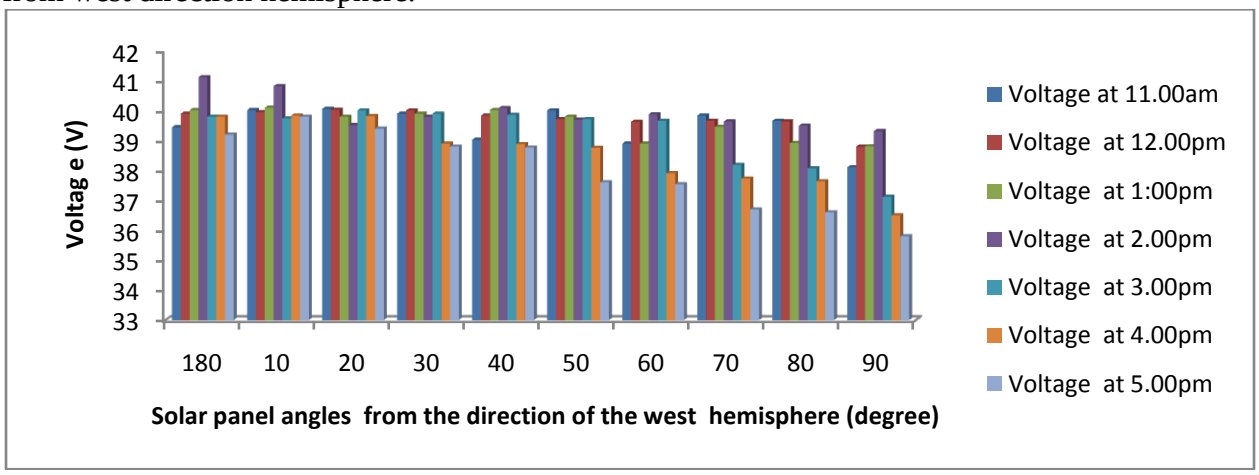

Fig 2. The obtained Voltage and corresponding Angles from the West Hemisphere direction

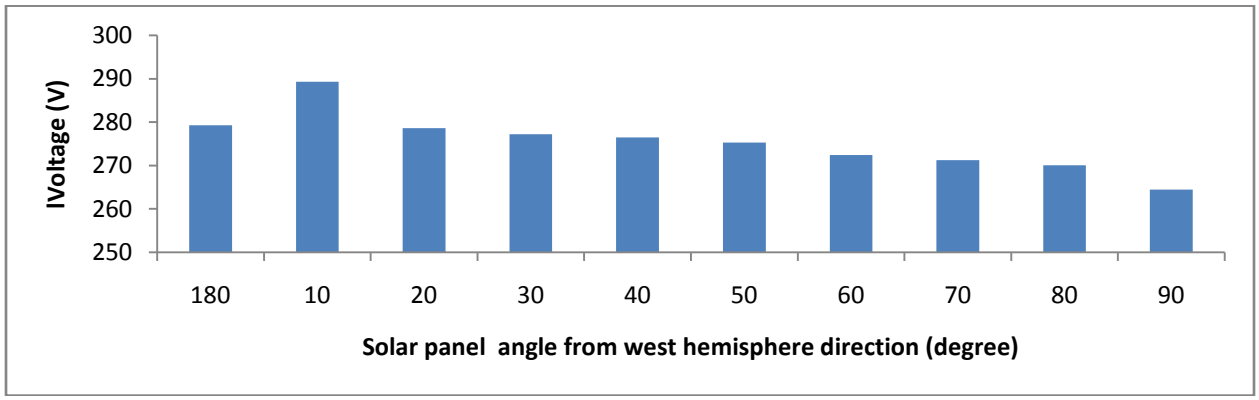

Fig. 3. The obtained Voltage and corresponding angles from the East Hemisphere direction

The total voltage obtained from the corresponding angles from the west hemisphere is shown in Fig 3. It is observed that angle 10^0 degree has the best output voltage from solar panel in direction of the west hemisphere.

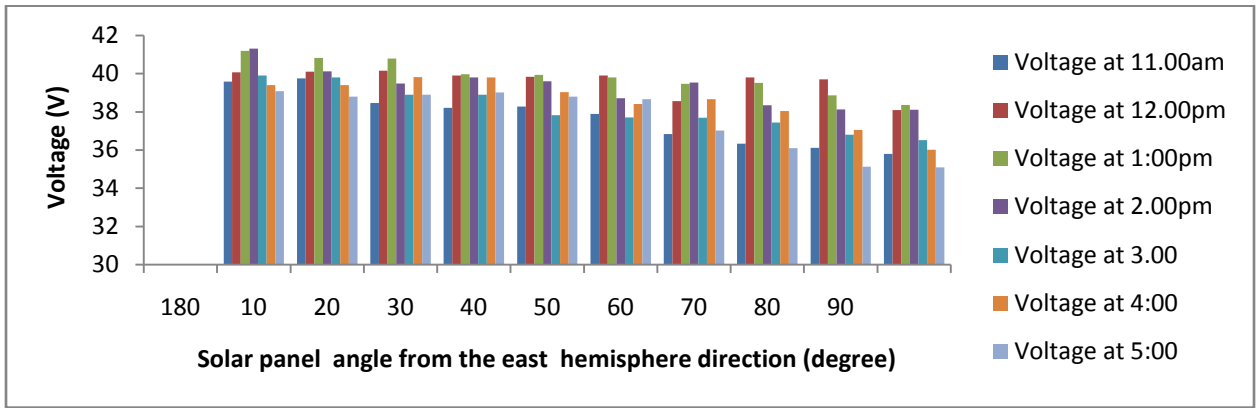

Fig 4. The obtained Voltage and corresponding angles from the East Hemisphere direction

Figure 4, shows the corresponding voltage in volt with various angles in degree and different time in hours. These corresponding voltages were obtained from solar panel output from East hemisphere direction.

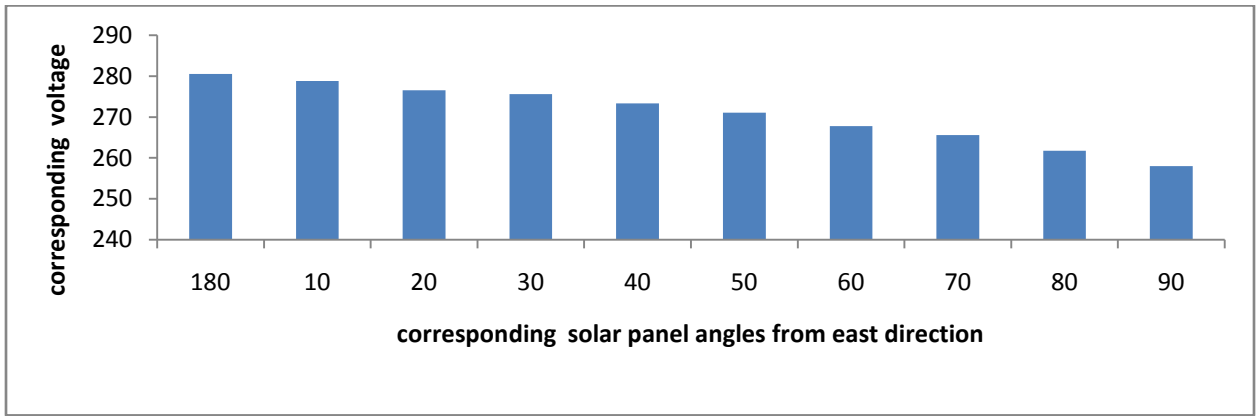

Fig 5. Voltage summation from the corresponding angles from the East Hemisphere direction

The total voltage obtained from the corresponding angles from the south hemisphere is shown in Fig 5, it is observed that angle 180^0 degree has the best output voltage from solar panel in direction of the east hemisphere followed closely by 10^0 degree. The comparison of the total voltage output between the West and East hemisphere direction of the solar panel is presented in Fig 6. It is observed that the total voltage output from the solar panel in the direction of the west hemisphere has the highest voltage (2745.32 Volt) compared with the solar panel in the direction of the East hemisphere voltage with 2709.06 Volts. The first bar column from the left is the voltage output from South hemisphere direction of the Solar Panel. While the second bar column from the left is the voltage output from South hemisphere direction of the Solar.

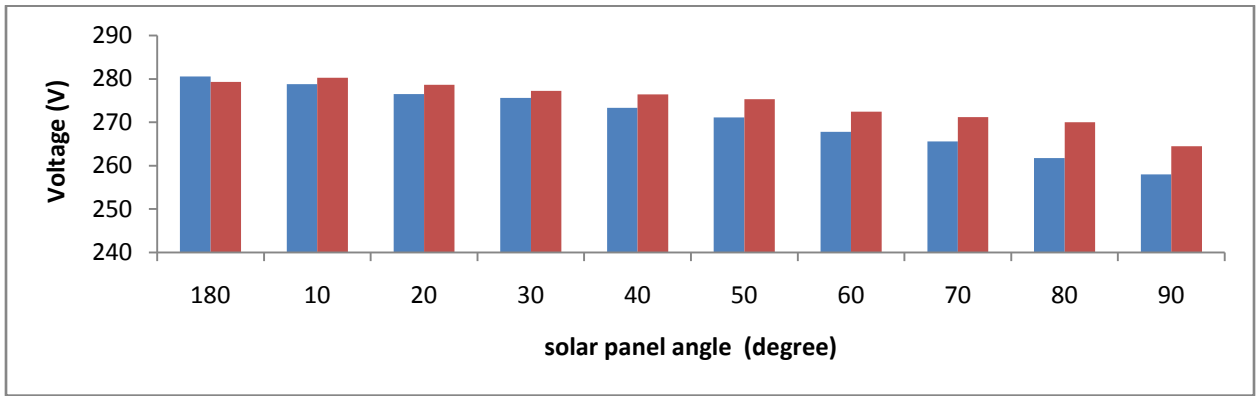

Fig 6. The comparison of the total Voltage output between the South and North Hemisphere direction of the Solar Panel.

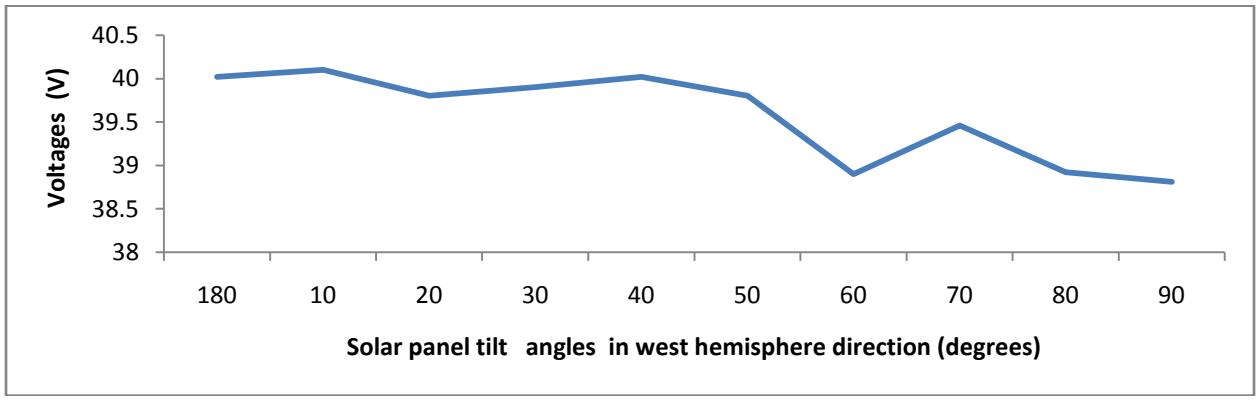

Fig 7.The output Voltages with the corresponding constant Angle at constant Time.

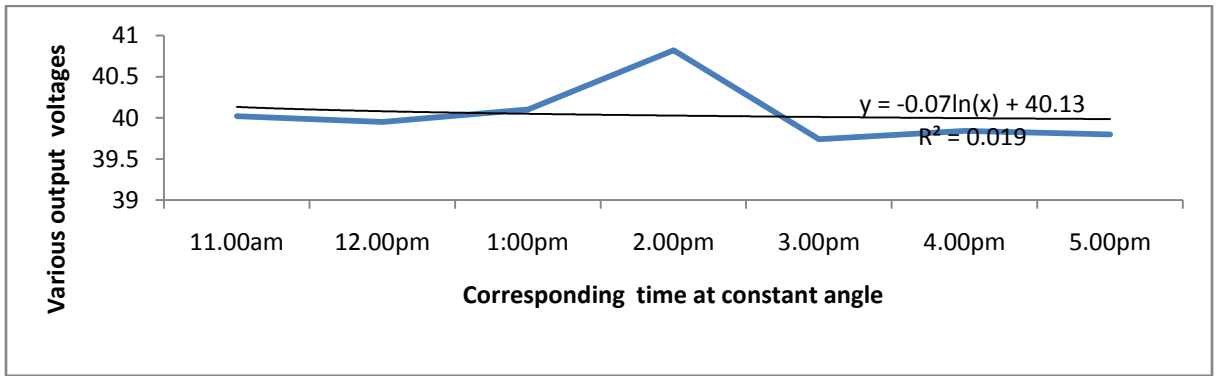

Fig 8. The Logarithmic Distribution Pattern of output Voltages with the corresponding time at constant Angle.

The maximum is obtained between 12.00 noon and 2.00 pm; however 1.00 pm has the highest output voltage from solar panel. This 1.00 pm followed the position of Nigeria in the global. Nigeria is situated at location of 1hour ahead the Greenwich meridian, while country like Ghana lies along the Equator, which imply that optimal voltage will be obtained at 12.00 noon. The output voltage from the tilt solar panel at 10^0 degree angle is modeled using excel program. It is observed, that the output voltage in a day, exhibits a logarithmic distribution pattern. Also, it possesses the least error or R squared value of 0.019 with corresponding equation.

$$y = -0.07\ln(x) + 40.13 \quad (1)$$

The logarithmic distribution is based on the standard power series expansion of the natural logarithm function, and thus is also known as the logarithmic series distribution, is a discrete probability distribution. The various voltages with the corresponding angles from the range of 180^0 degree to 90^0 degree were shown, it observed from the investigation that 10^0 degree angle has the highest voltage in the direction of west hemisphere, therefore to obtain maximized voltage from the solar panel, 10^0 degree angle should be used as the tilt angle for solar panel in direction of west (Sun set) direction.

4. CONCLUSION

This research work is aimed at obtaining optimal voltage from solar panels from the daily sunlight, the voltage served as alternative power source to conventional power supply. The major factor considered in this research was to determine the output Voltage from solar panels as various tilt angles of the solar panels. The experiment was carried out at Ambrose Alli University Ekpoma, situated between longitude 6^0 10' to 60^0 40' and latitude 60^0 10' to 60^0 40', which involves the use of solar panel, protector, Voltmeter used to measure the voltage from the precision tilt angles. The voltage and corresponding angles were presented for both the East and West Hemisphere direction in Fig 2 and Fig 4. Voltage summation from the corresponding angles from both the East and west hemisphere were shown in Fig 3 and Fig 5. The output voltage with the corresponding constant angle at constant time is shown in Fig 6. The modeling was determined using excel software, it is observed that the output voltages with variable time at constant angle in a day, followed a logarithmic distribution pattern. The logarithmic distribution pattern possesses the least error or R squared value of 0.019 with corresponding equation.

REFERENCES

Dobrzanski, L.A., Drygala, A. and.Januszka, A. (2009), Formation of photovoiltaic modules based on polycrystalline solar cells, Journal of Achievement in Materials and Manufacturing Engineering, Volume37, Issue 2,Pp 54-59.

Enda Flood, McDonnell, K F., Murphy and Devlin, G. A., (2011) Feasibility Analysis of photovoltaic solar power for small communities, The Open Renewable Journal, 2011,4 page 78-92.

Evbogbai M.J.E, Ogieva, F.E and Osahenvemwen, A.O., (2009) Voltage-time characteristic of a solar panel in Ambrose University, Ekpoma Nigeria, International Journal of Electrical and Power Engineering 3(1):31-35,ISSN:1990-7958.

Fawaz Sultan, Firas Aziz Ali, and Tariq Khalid A. Razaq, (2012), Tilt Angle Optimization of Solar Collectors for Maximum Radiation in Three Iraqi cities, International Journal of Engineering and Industries (IJEI), Volume 3, Number 4, .Issue 4.11 page 99-107.

Felix A. Uba and Emmanuel A. Sarsah (2013) Optimization of tilt angle for solar collectors in WA, Ghana, Pelagia Research Library Advances in Applied Science Research, Vol. 4 (4): page 108-114.

Kreith F. and Kreider J.K, (2012) Principle of sustainable Energy, Journal of solar Energy Engineering,CRC press, Pp 45-51.

Photovoltaic solar energy Development and current research, available at http://ec.europa.en/energy/publications/doc/2009_ report-solar-energy.pdf, [Accessed: March 12, 2013].

Pijush kanti Bhattacharjee, (2010), Solar-Rains-Wind lightning Energy source power Generation system, International Journal of Computer and Electrical Engineering, Vol.2, Pp1793-8163.

Rizk, J and. Nagarial, M.H. (2009), "Impart of Reflectors on solar Energy systems", International Journal of Electrical and Electronics Engineering, Pp 3-9.

Solar energy, available at http://en. Wikipedia.org/wiki/solar-energy, [accessed: April 4, 2013].

Theoretical and practical limits on solar energy conversion: Why use nanostructured materials, available at http//:www.pa.msu.edu/~duxbury/cnd/solar efficiency.pdf, [Accessed: March 1, 2013]

Theraja, B.L. and Theraja, A.K., (2004), Electrical Technology, Publication Division of Nirja Construction and Development Co. Ltd New Delhi-110055, Pp1759-1782.

Reducing variation in solar Energy supply through Frequency Domain Analysis, available at http:iiitb.biz/srao/paper/solar/2011, [accessed: 2/1/2013].