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Research Article

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Experimental Study to Evaluate the Performance of Flat Plate Solar Collector using Water Flow

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Abstract The need for quality, environment friendly and un-interrupted power supply has called for renewable energy as an alternative source. In this work, we studied how to make a flat plate solar collector performance more efficient using water flow, increased number of riser pipes and reduced space between the glass cover and the absorber surface. Water-type collector that use water as heat transfer fluid was adopted. The collectors were mounted independently on a solid surface inclined at angle 30^o to the direction of the sun's radiation at Nekede area in Owerri West Local Government Area of Imo State. We considered two different peak seasons during the measurement; rainy season during the month of July and dry season during the month of December 2017. A reservoir tank of 150 liter capacity was used and filled with cold water. At the outlet of the reservoir tank was a control tap used to control the flowing water to the flat plate collector. Another empty tank used as the storage tank was mounted 100cm above the collector surface. The solar flat plate collectors were allowed to receive the sun's radiation for an hour, 8.00 am – 9.00 am before the liquid medium was allowed to flow through the pipes. The tube connected from the cold water tank to the inlet of the collector was adjusted and the tap slightly opened to allow the fluid flow into the pipes. At the outlet of the collector, it was made open to flush out the air that may have occupied the space in the pipes before the water started flowing. This process continued for one hour in intervals of ten minutes each. The temperature of the cold water was measured from the reservoir outlet. These procedures were carried out on the two collectors used. After taken the temperature of the water from the collector outlet, the tube was connected so that the water can be transferred to the storage tank by the natural occurrence. The water in the storage tanks and reservoirs were measured hourly. Figures 1-7 showed the behavior of change in temperature of the fluid and the number of riser pipes in the collector. The outlet temperature was higher than the inlet temperature measured. This explained the absorption of heat by the glazing material at the surface of the flat plate collector and the heat transferred to the liquid medium in the pipes. The fifteen riser pipes have higher temperatures than the ten riser pipes. This expressed retention of heat. Finally, solar collector with more riser pipes gave a better output and higher efficiency at the two seasons.

Keywords Flat Plate, Solar Collector, Water Flow

Introduction

Electricity production and supply in Nigeria has been a monopoly of the federal power electric utility body known as National Electric Power Authority (NEPA). This utility was charged with the responsibility of power generation, transmission, distribution and sale of electricity to customers. The reform that is taking place in the electricity sector in the world is increasing rapidly. Both developed and developing countries have embarked on a program of liberalizing and stabilizing their power sectors to ensure an available electricity supply that is stable. The establishment of NERC (National Electricity Regulatory Council) is one of the main pillars for ensuring the delivery of efficient and stable power supply especially in Nigeria yet it is not feasible [1]. We must find ways to store the large quantities of electricity and heat that we will produce.

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 1.8×10^{11} MW, which is many times larger than the present rate of all the energy consumption, Chandraker et al. [2]. Access to solar energy is interrupted by natural cycles of day-night, cloudy-sunny, and winter-summer variation that are often out of phase with energy demand. The few number of tubes employed in the solar power absorber reduces drastically the efficiency of the flat plate solar collector. Many researchers have made their research using different fluids to improve on the efficiency of the solar collector. It was observed that all the fluids employed (acetone, methanol, ethanol, ammonia) are hazardous to health and will affect some materials in use except water. In this research work, we made a flat plate solar collector performance more efficient by using water flow, protecting the solar collectors and panels from birds of the air and their nest, so that the birds will not destroy or reduce the absorber rate of the collector. This approach was to improve the efficiency and guarantee the safety of the usage. It was seen to be implemented for domestic and industrial use to serve the following purposes: to use water as moving fluid through the pipes and to evaluate the efficiency of the flat plate solar collector as it transmits heat radiation to the liquid. Here, we focused on the influence of operating parameters on flat plate collector [3-6].

Materials and Methods

Flat plate collectors have had many solar collector concepts presently being developed. They can produce heat energy to the residential and commercial buildings or areas where it is needed at sufficiently high temperatures to heat swimming pools, domestic hot water, and buildings, operate cooling unit [7]. Flat plate solar collectors are classified into water-type (hydronic) collectors – that use water as the heat transfer fluid. The air-type collectors – use air as the heat-transfer fluid. In this study, water-type was adopted. All the components of the flat plate solar collectors used were coupled according to the specification of the designer. There were two types of the flat plate collector used in this study to evaluate their performances. They were made with the same materials but have different number of riser-pipes and variation in the space between the pipes. The collectors were mounted independently on a solid surface inclined at angle 30^o to face the direction of the sun's radiation at Nekede area in Owerri West Local Government Area of Imo State situated at latitude 5.48 ^{o}N and longitude 7.02 ^{o}E. We considered two different peak seasons during the measurement; dry season during the month of December 2017 and rainy season during the month of July 2017.

A reservoir tank of 150 liter capacity was used and filled with cold water. At the outlet of the reservoir tank there was a control tap used to control the flowing water to the flat plate collector. Another empty tank used as the storage tank was mounted 100cm above the collector surface. The solar flat plate collectors were allowed to receive the sun's radiation for an hour (8.00 am – 9.00 am) before the liquid medium was allowed to flow through the pipes (when no load). The tube connected from the cold water tank to the inlet of the collector was adjusted and the tap slightly opened to allow the fluid (water) flow into the pipes. At the outlet of the collector, it was made open to flush out the air that may have occupied the space in the pipes before the water start flowing. This process continued for one hour in intervals of ten minutes each. The heats generated by the hot air as a result of heat radiation coming out were measured using the lux-meter. Thereafter, the tube from the storage tank was connected to the outlet of the collector. Before the entire process above, the temperature of the cold water was measured from the reservoir outlet and also the temperature of water from the collector's outlet. These procedures were carried out on the two collectors used. After taken the temperature of the water from the collector outlet, the tube was connected so that the water can be transferred to the storage tank by the natural occurrence (thermo-syphon principle). Every intervals of one hour, the water in the storage tanks and reservoir tanks were measured.

Results and Discussion

The results of the data collected from the two flat plate collectors as determined by their riser pipes were presented on the graphs of figures 1-1 below;

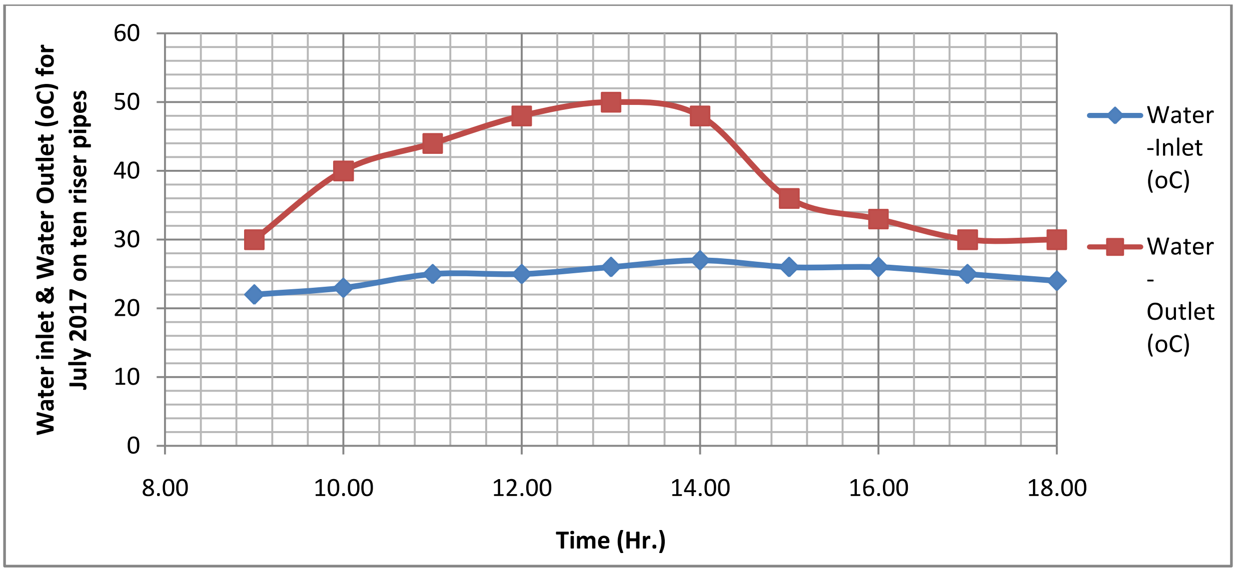

Figure 1: Graph of water inlet and outlet temperature (^oC) on ten riser pipes for July 2017

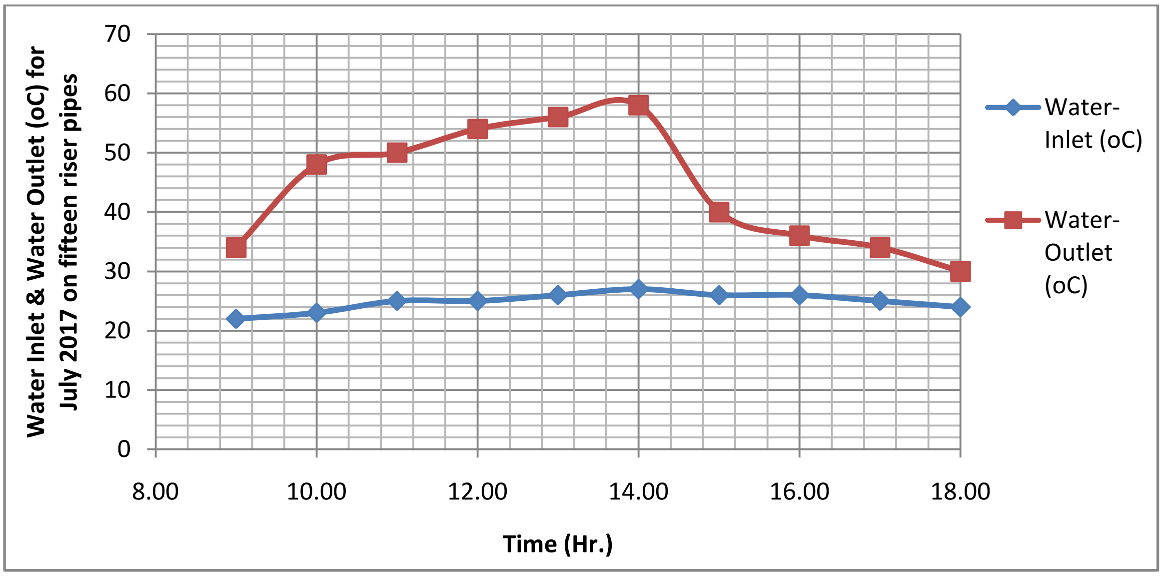

Figure 2: Graph of water inlet and water outlet temperature (^oC) on fifteen riser pipes for July 2017

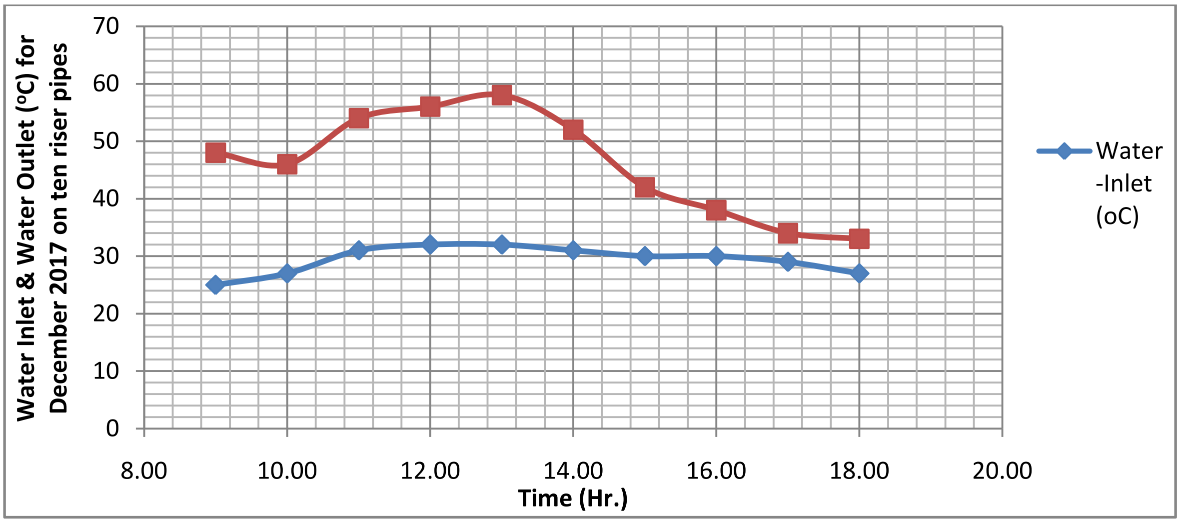

Figure 3: Graph of water inlet and water outlet temperature (^oC) on ten riser pipes for December 2017

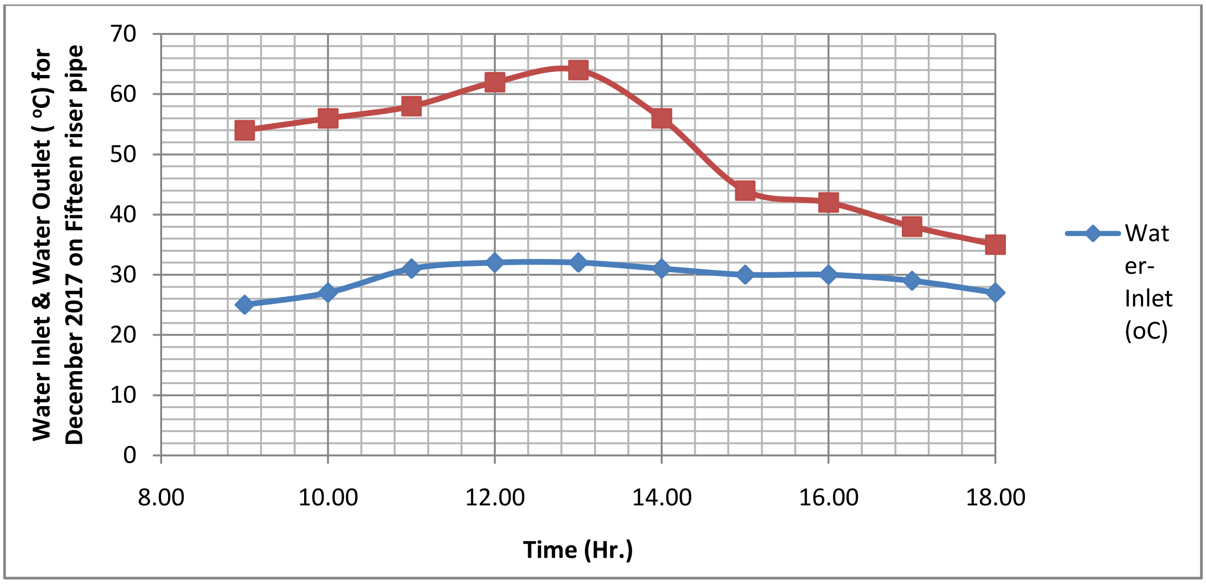

Figure 4: Graph of water inlet and water outlet temperature (°C) on fifteen riser pipes for December 2017

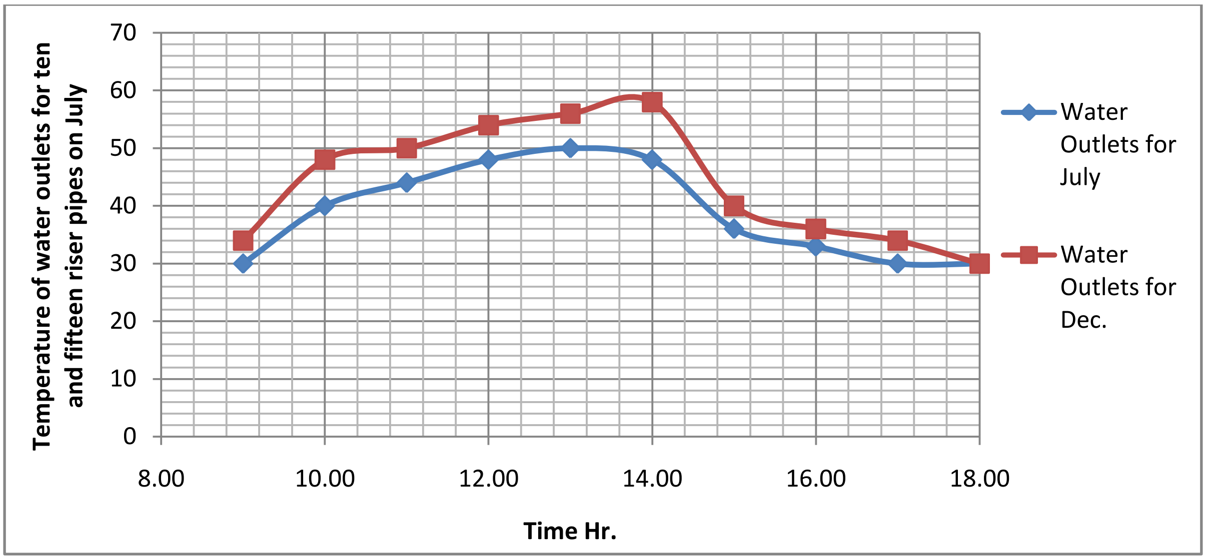

Figure 5: Graph of temperature on water outlets for ten and fifteen riser pipes for July 2017

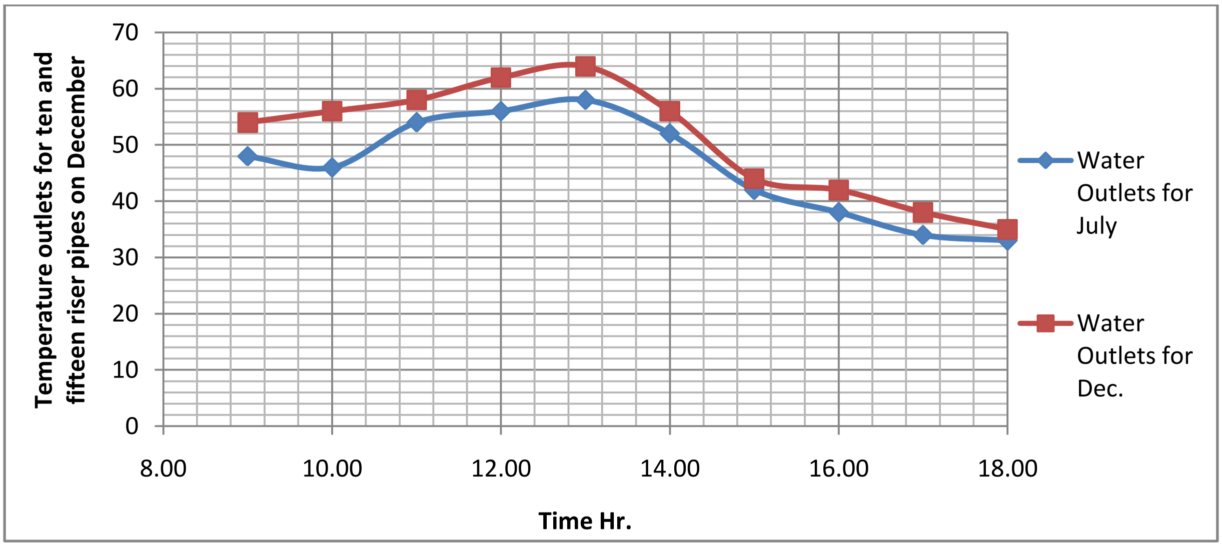

Figure 6: Graph of temperature on water outlets for ten and fifteen riser pipes for December 2017

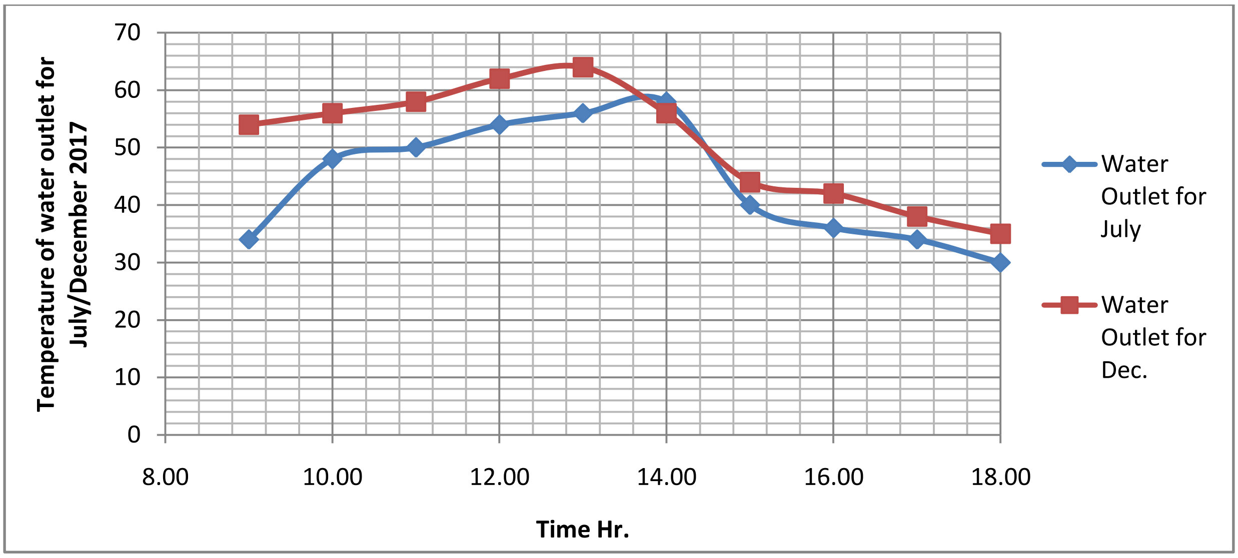

Figure 7: Graph of temperature of water outlets for July and December 2017

From the figures above, the behavior of change in temperature of the fluid (water) and the number of riser pipes in the collector showed obvious differences on the graphs. Figures 1–4 showed wide range of differences on the graphs. The outlet temperature was higher than the inlet temperature measured. This explained the absorption of heat by the glazing material at the surface of the flat plate collector and the heat transferred to the liquid medium in the pipes. The fifteen riser pipes have higher temperatures than that of the ten riser pipes. This expressed the retention of heat. From all indications, solar collector with more riser pipes gave a better output and higher efficiency at the two seasons. It gave increased efficiency at the hot season than the dull season.

Figure 1 was the graph of water inlet and outlet temperature measured on the flat plate collector with ten riser pipes. The temperature of the water inlet was measured before it was allowed to flow into the flat plate collector. While the temperature of the water outlets was measured as water flow out of the collector through the ten riser pipes and the header pipe for July 2017. Figure 2 showed the graph of water inlet and outlet temperature measured on the flat plate collector with fifteen riser pipes. Again, the temperature of the water inlet was measured before it was allowed to flow into the flat plate collector. While the temperature of the water outlets was measured as water flow out of the collector through the fifteen riser pipes and the header pipe for July 2017. Figure 3 was the graph of water inlet and outlet temperature measured on the flat plate collector with ten riser pipes. The temperature of the water inlet was measured before it was allowed to flow into the flat plate collector. While the temperature of the water outlets was measured as water flow out of the collector through the ten riser pipes and the header pipe for December 2017. Figure 4 showed the graph of water inlet and outlet temperature measured on the flat plate collector with fifteen riser pipes. Again, the temperature of the water inlet was measured before it was allowed to flow into the flat plate collector. While the temperature of the water outlets was measured as water flow out of the collector through the fifteen riser pipes and the header pipe for December 2017. From figure 1–4, it was seen that the output of the outlets (fluid) were having higher temperature than the inlets. Figure 5 was a graph that compares the two riser pipe's outlets for the month of July 2017. Again, the graph of Figure 6 compared the two riser pipe's outlets for the month of December 2017. From the graph of 5–6, it was evident that the fifteen riser pipes collector was having higher temperature which showed more efficiency. The graph of figure 7 shows the behavior of the fifteen riser pipes water outlets for the two seasons (July and December 2017). The result of the fifteen riser pipes for December 2017 was more efficient. The hot season contributed to the efficiency of the collector.

Conclusion

The fifteen riser pipes have higher temperatures than that of the ten riser pipes. The flat plate solar collector with more riser pipes gave a better output and higher efficiency at the two seasons. Therefore, result from the graphs will in no small measure help to determine when the flat plate solar collector will be better put to use in terms of season.

References

[1]. Adoghe et al. (2010), "Power sector reforms – effects on electric power supply in Nigeria". An article published in International Journal of Electrical Power Engineering (IJEPE), Vol. 3, 2009. pp 36 – 42.

[2]. Chandraker et al. (2014), "Experimental study on hybrid power combining solar energy and animal energy for home cooking system". www.ripublication.com/ijerd.htm

[3]. Chen J.C. (2011), "Physics of Solar Energy". John Wiley and Sons Inc., Hoboken, New Jersey. pp 2-4.

[4]. Kumar et al. (2012), "Experimental study of optimum tilt angle for solar PV panel in Jaipur (Rajasthan)". IJSR 2012.

[5]. Waheb H.J. (2015), "Experimental study of the performance of flat plate solar collector with natural circulation". Journal of Energy Technologies and Policy; Vol. 5, Nos. 6, 2015.

[6]. Yinghao C. (2011), "Review and comparison of different solar energy technologies". Global Energy Network Institute, August 2011.

[7]. Amrutkar et al. (2012), "Solar flat plate collector analysis". IOSRJEN. Vol 2 issue 2, Feb. 2012, PP. 207-213.