# Performance of Solar Water Heater in Akure, Nigeria

Samson A. Arekete
Mathematical Sciences Department, Redeemer's University, Redemption City, Mowe, Nigeria
E-mail: Samson_Arekete@yahoo.com

**Abstract**
Solar water heating is a process of tapping energy from the sun for the purpose of raising the temperature of water from local water supply to some desirable higher temperature. Water left in a container and exposed to the sun, has been observed to increase in temperature. However, this natural gain of temperature is not usually efficient; partly because water is a poor absorber of solar energy and partly because a large chunk of energy gain is used in evaporation of water, which will not result into temperature raise. A solar water heater was designed, constructed and tested in Akure, South West, Nigeria (Latitude 7.30$^{o}$N and Longitude 5.25 $^{o}$E). A flat plate collector covered with double glazing layers at 20$^{o}$ angle of tilt to the horizontal was employed. The surface of the collector was darkened to improve its absorption capacity. Readings were taken for a period of six days. With an ambient temperature of 36$^{o}$C, a maximum hot water temperature of 73$^{o}$C was recorded during the experiment. In addition, hourly collector's efficiency increased slightly until 2.00 when steep increase was obtained which peaked at 92% at 4.00 pm. The outcome of the experiments established the fact that solar water heater is feasible in South West Nigeria, and of course, in most parts of the country, since insolation is even higher in most other parts of the country, particularly South East and the Northern regions.
**Keywords:** Solar water heater, insolation, radiation, solar energy, thermosiphon.

## 1. Introduction

Solar water heating is one of the prime application areas of solar energy. According to (Kishor et al., 2010) water heating by solar energy for domestic use is one of the most successful and feasible applications of solar energy. Other areas of application of solar energy include solar drying, electricity generation using photovoltaic cells, solar cooling and refrigeration, solar still (or solar distillation) and solar cooking. An ambitious solar plan that would result in the generation of 20,000MW of solar energy by 2022 had been put in place by India (Renewable Energy World, 2009).

Using the sun's energy to heat water is not a long known idea (Marshall, 2009). The Romans warmed their baths with large south-facing windows and modern-prototype solar water-heating systems of copper tubes in glass-enclosed boxes were already invented by the late 1800s. These pioneering forays, however, seemed to be lost on Americans until the 1970s, when oil shortages prompted the then President Jimmy Carter to grant generous federal and state solar-energy tax credits for solar water heaters. Solar water heating has been reported to enjoy much popularity in places like Australia, Israel, the United States of America, Germany, Sweden, India, Jordan, Cyprus, China, Greece and Japan (Reeves, 2009; Garg, 2009). Nigeria, like many other tropical countries are blessed with abundant solar energy which is beamed over the geographical entity and received freely on daily basis.

Tapping solar energy for the purpose of heating water is based on a simple natural phenomenon. Cold water in a container exposed to the sun undergoes a rise in temperature. However, this natural temperature gain is usually very low, being only a few degrees Celsius. The reasons for this low temperature gain are twofold. One reason is due to the low heat absorption of water. The second reason is because much of the heat that is absorbed goes into increase evaporation, a change of state from liquid to gas phenomenon, thus reducing temperature rise. A solar water heater employs a solar collector with good absorption capacity and with the ability of collecting energy from over a wider area and harnessing the energy collected to raise the water temperature significantly. The issue of evaporation of the working liquid is significantly minimized since the fluid flow is within insulated pipes and storage tank. Solar water heaters, also called solar domestic hot water systems, can therefore be a cost-effective way to generate hot water. They can be used in any climate, and the fuel they use the most, sunshine, is absolutely free (Revees, 2009).

There are two basic types of solar water heating systems on the market, one known as passive (no pumps, also called thermosiphon system) and the most popular known as active, which has pumps that circulate heated water through the system. Solar collectors are of three main types — evacuated tube, copper glazed and polymer. Traditional glazed collectors are large heavy glass covered boxes that need roof loading engineering equipment or cranes to install. On the other hand, polymer collectors are lightweight and are easy to install by one person and require no roof loading or special equipment to install (Revees, 2009). A passive solar design works without any pumps or electric components. This makes them less vulnerable to mishaps, easier to maintain, and possibly longer-lasting than active systems. The simplicity also tends to mean that they are less expensive than active systems, but the trade-off is that they are typically less efficient (Marshall, 2009). According to (Kishor et al., 2010), flat-plate collectors are the most economical and popular among domestic solar water heating systems since they are permanently fixed in position, have simple construction, and require less maintenance.

The main components of a solar water heater are a flat plate collector and a large insulated storage tank with pipes fitted between them to convey cold water from the bottom of the storage tank to the inlet of the collector at the base and hot water from the outlet of the collector at the top, to the top of the storage tank. The collector, which is the most critical part of the solar heating system, is where solar radiation is absorbed and energy is transferred to the fluid. The flat plate collector absorbs both beam and diffuse radiation, as such it still functions when beam radiation is cut off by cloud covering. This advantage, together with favourable cost suggested the reason for choosing a flat plate collector for this experiment.

In a practical solar water heater installation, by mounting the collector plate on the roof top with the storage tank located above the collector, the hot water is supplied to the storage tank by the principle of thermosiphon. A thermosiphon system, therefore, is a passive setup that relies on a phenomenon of natural convection (warm water rises) to circulate water through the collectors and to the tank. In this arrangement the tank must be above the collector. This creates a pressure gradient which enables water to flow from the tank to the bottom of the collector. When water in the collector heats up, it becomes lighter and rises naturally into the tank above. As this happens, cooler water in the tank flows down pipes to the bottom of the collector, creating circulation throughout the system. Because of this density differential created by the temperature gradients, the water will continue to circulate without any external source other than sunlight. This effect of convective self-flow is generally referred to as thermosiphon effect (Meinel and Meinel, 1976) and Szokolay (1975). Storage tank is attached to the top of the collector so that thermosiphon can occur.

Thermosiphon systems have the advantage that under low or no sunshine, the temperature of water in the collector and the supply leg are similar and circulation automatically stops, leaving the warm and less dense water in the storage thank above the cooler and denser water in the collector and the pipe lines. The thermosiphon system is thus suitable in solar applications where circulation is automatically controlled. It is in fact true that circulation rate dances to the tune of insolation intensity. Thermosiphon systems are also the best for rural areas where electricity may not be available for pumping. Thermosiphon systems are not appropriate for cold climates because when temperature drops below 0°C, the water in the system freezes. Some thermosiphon systems address this problem by circulating an antifreeze solution through a heat exchanger (so the antifreeze solution does not contaminate the household water), but this is not enough to make such setups freeze-proof during extended cold periods (Marshall, 2009). The use of a closed loop system for solar heating in temperate regions that are susceptible to freezing has also been reported (Solar Power Talk, 2009).

Hot water is needed all the year round for diverse purposes. Using a conveniently located heater energized by flame or electric element, it is possible to raise the temperature of water from about 25$^o$C, the usual temperature of water from the local water supply to about 60$^o$C. To do this for both domestic and industrial demands, however, would take a substantial portion of our scarce energy. Each kilogram of water warmed requires 1000 calories of heat for each degree Celsius rise in temperature. Thus, 35 kilocalories of energy are required to warm each kilogram from 25$^o$C to 60$^o$C. This is an enormous demand on our limited energy supply and a huge cost when one uses our current unit cost of electricity to calculate it. Since most hot water requirements fall below 60$^o$C, these requirements can easily be met through solar water heating. On the other hand, when higher temperature is required, it would be a lot cheaper to heat water from 60$^o$C to the required temperature than to start from 25$^o$C. In that case, solar water heater can serve as a pre-heater. According to Garg (2009) solar water heater can in fact raise water temperature from ambient temperature to about 100$^o$C under the best conditions.

Nigeria enjoys an average of 11 to 12 hours of sunshine almost every day in the year and it should not therefore be difficult for solar water heater to perform well on most days of the year in any parts of the country. The need to protect our conventional sources of energy has also become apparent. We are not sure our oil will not be depleted in a couple of decades from now since it is not a renewable energy source. Electricity has not reached most of the small towns and villages in the country and it has also not been stable in the towns and cities especially with increasing level of industrialization in the country couple with the drop in electricity capacity generation. Since nature has been generous to bless us freely with abundant sunshine, it is wisdom for us to tap this wasting but very useful source of energy for our own benefits. In addition, whereas electricity and gas are not available in every locality, solar energy is distributed equally by God to all parts of our country, which mean that solar heating will not suffer from geographical limitations. Hot water is needed for a myriad of purposes at home, in the hospital and the industry almost all round the year. A greater percentage of hot water requirements usually fall below 60oC. Solar energy can easily be harnessed to meet a significant proportion of hot water demands in Nigeria.

The development, modelling and analysis of thermosiphon solar heating system have been reported in literature. An early published analysis of a thermosiphon solar water heating system was reported by Close (1962); he worked on analysis of circulation rates in natural circulation systems and compared the predicted and experimental inlet and outlet water temperatures. Gupta and Garg (1968) modified the basic model outlined by Close (1962) to account for the system capacity and heat exchanger efficiency of the absorber and heat losses in connecting pipes. A mathematical model was developed by Ong (1974) using a finite-difference method of solution for predicting the thermal performance of a flat-plate solar water heater operating under natural convection (thermosiphon) flow and compared the predicted results with experimental values obtained at Malaysian weather conditions. Zvirin et al. (1977) presented the natural circulation solar heater model with linear and nonlinear temperature distributions. Morrison and Ranatunga (1980) developed a laser anemometer to eliminate the problem of flow restriction and to provide the comparatively fast response needed to measure transient flow rate in thermosiphon operation. Morrison and Tran (1984) used finite-element simulation model for predicting the long term performance of thermosiphon solar water heaters. The research also presented the simulation results and compared them with the experimental parameter for performance of six systems supplying typical domestic hot water loads. Prapas (1995) underscored the need for optimization of system performance to the ultimate limit possible and the performance examination from user point of view. Hasan (1997) used the TRNSYS program to simulate the thermosiphon solar water system. The theoretical analysis by computer simulation of a two-phase solar water heating system is demonstrated using R-11 as a working fluid (Joudi and Al-Tabbakh, 1999). Various other researchers have reported the analysis and modelling solar water heating systems (Hussein *et al*. 1999, Kalogirou *et al*. 1996, Kalogirou and Panteliou, 2000, Bojic´ *et al*. 2002, Za´rate *et al*. 2003, Za´rate *et al*. 2006).

The rest of the paper is organised as follows: section 2 presents the experimental methods adopted in this study. The theoretical performance evaluation technique is presented in section 3 while section 4 contains the results of the experimental setup. Conclusions are drawn in section 5.

## 2. Materials and Method

The experimental solar water heater comprised basically of a flat plate collector and an insulated storage tank interconnected by supply and return pipes. A 90cm x 60cm x 0.2cm galvanized iron sheet was used. Aluminum or copper plates, which are of better conductivities would have been used but for their cost. The top and lower headers are made up of 1.3 cm diameter copper pipes while the risers have copper pipes of diameter 0.9cm. The risers and the headers constitute the water passages and they are bond to the absorber plate with 5cm wide iron sheets by riveting. The entire surface was painted black to make it a good absorber of heat.

A wooden box made of plywood with dimensions 93cm x 65cm x 25cm was used for the casing. Two glass sheets of dimension 90cm by 60 cm and 4mm thickness are used as transparent cover. The assemblage of the blackened absorber plate, the glass covers and the casing constitute the flat plate collector, which is the heat exchanger. The space between the two glass-covers was 4cm. Sawdust was used to provide insulation behind the absorber plate. A 50 litre container was employed as the storage tank. This was insulated with sawdust which was sandwiched between the storage tank and the bigger box in which it was contained. The return and supply legs were also properly insulated. The storage tank was placed 70 cm above the collector.

The whole setup was supported with a framework constructed with 1 inch diameter lead pipes. The setup of the framework was such that the collector was tilted $20^{O}$ to the horizontal and the tank was 70cm above it. Both the casing and the glass covers serve as weather-proof container for the collector plate. In addition, the glass covers also reduce convective and radiation losses of heat to the atmosphere. Figures 1 depict the constructions of the solar water heater.

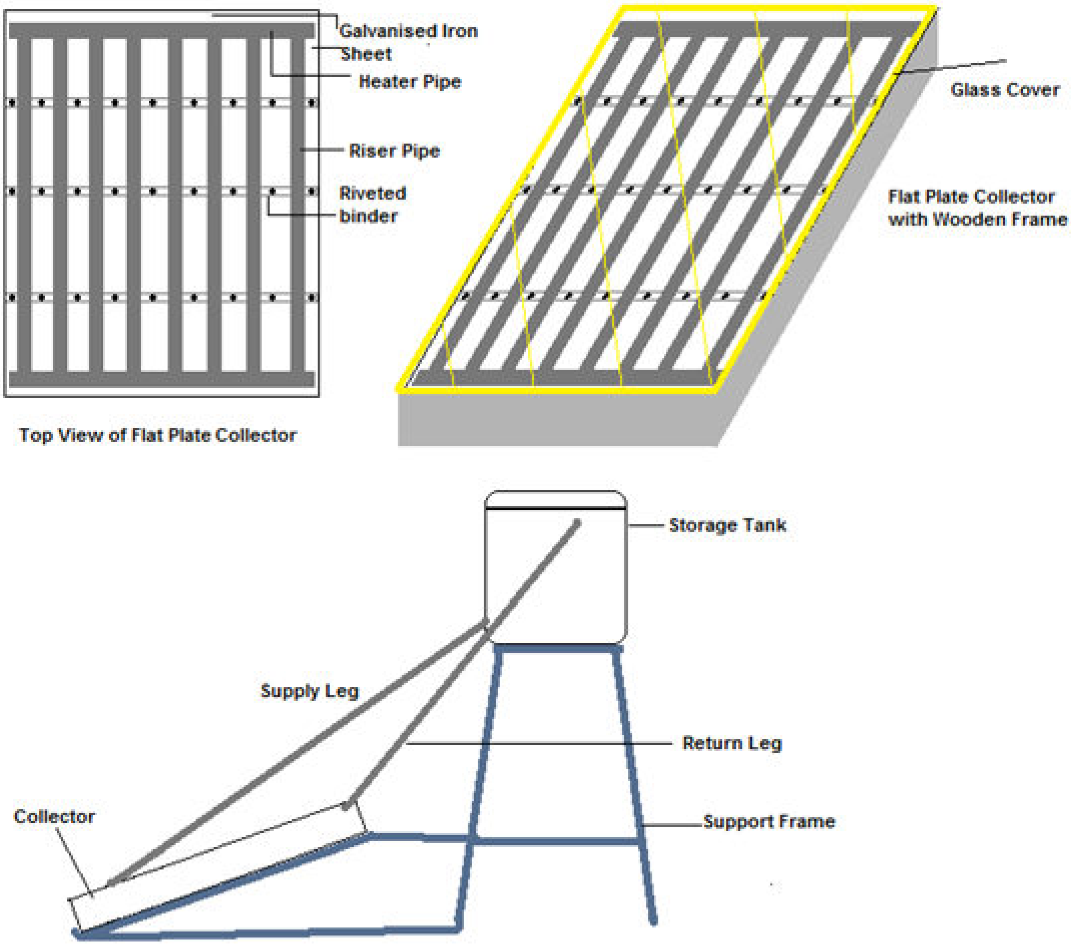


**Figure 1 Solar Water Heater Setup**

## 3. PERFORMANCE EVALUATION

The thermal efficiency of the solar water heater as a performance parameter was evaluated. The radiant flux ($R_f$) striking the flat plate collector:

$$R_f = \tau_{cov} A_p G \dots \dots \dots \dots (1)$$

where $G$ = the irradiance on the collector
$A_p$ = exposed area of the plate
$\tau_{cov}$ = the transmittance of the transparent cover
Only a fraction , $\alpha_p$, of the flux is actually absorbed. Since the plate is hotter than the environment, it loses heat at a rate

$$\frac{T_p - T_a}{R_L}$$

where $R_L$ = resistance to heat loss from the plate (temperature $T_p$) to the outside environment (temperature $T_a$). The net heat flow into the plate is

$$P_u = \tau_{cov} \alpha_p A_p G - \left[ \frac{(T_p - T_a)}{R_L} \right] = \eta_c A_p G \dots \dots \dots \dots (2)$$

where $\eta_c$ = captured efficiency (<1)

This is called Hottel-Whiller equation (Twindell and Weir, 1986)

Generally, only a fraction, $\eta_{pf}$ of $P_{net}$ is transferred to the fluid at the temperature $T_f$. For a well-designed collector, the temperature difference between the plate and fluid is small and the transfer efficiency $\eta_c$ is only slightly less than 1. Thus the useful output power from the collector is

 

$$P_u = \eta_c P_{net} = \dot{m}c(T_2 - T_1) \ldots \ldots \ldots (3)$$

if a mass $\dot{m}$ flows through the collector per hour, $T_1$ = temperature of water entering the plate, $T_2$ = temperature of water leaving the plate.

A collector of area $A_p$ exposed to irradiance G measured in the plane of the collector gives a useful output

$$P_u = A_p q_u = \eta_c A_p G \ldots \ldots \ldots (4)$$

from (3) and (4), the thermal efficiency $\eta_c$ becomes

$$\eta_c A_p G = \dot{m}c(T_2 - T_1) \ldots \ldots \ldots (5)$$

Hence

$$\eta_c = \frac{\dot{m}c(T_2 - T_1)}{A_p G} \ldots \ldots \ldots (6)$$

The efficiency can be estimated by the formula:

$$\eta_c = \frac{\dot{m}c(\Delta t)}{A_p I} \ldots \ldots \ldots (7)$$

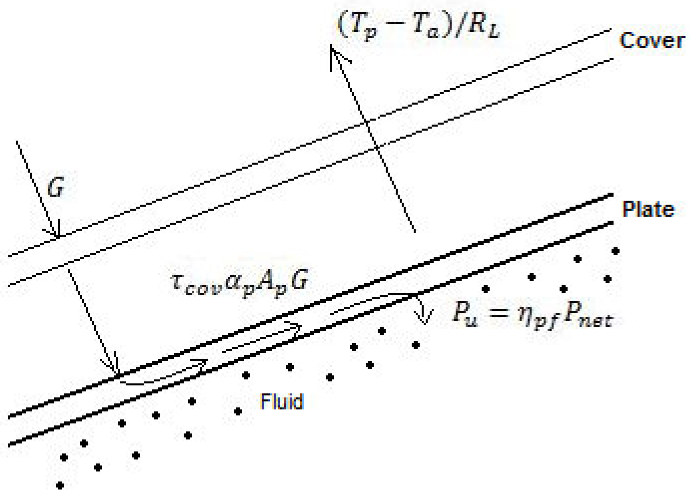


**Figure 2: Flow of Heat in the Collector**

where $\Delta t = T_{in} - T_{air}$, $T_{in}$ is temperature of water entering the collector, $T_{air}$ is ambient temperature and $I$ = Radiation Intensity (W/m$^2$). Equation 6 is therefore adopted in the calculation of efficiency. To calculate mass flow rate, volumetric flow rate of water was measured and the average value obtained was 0.89 x 10$^{-3}$ m$^3$/s, the density of water = 10$^3$ kg/m$^3$ and total flow area was 9.02x10$^{-4}$ m$^2$.

$$\therefore \dot{m} = 0.89 \times 10^{-3} \times 10^3 \times 3600 \times 9.02 \times 10^{-4}$$

$$=2.9 \text{ kg/hm}^2$$

The specific heat capacity of water = 4.18kJ/kg$^o$C and the collector plate area was 90cm x 60cm = 0.54m$^2$. Hence,

$$\eta_c = \frac{2.9 \times 4.18}{0.54} \times \frac{\Delta t}{I} = 22.35 \frac{\Delta t}{I} \ldots \ldots \ldots (8)$$

## 4. RESULTS AND DISCUSSION

The complete solar water heater was tested for a period of six (6) days. The experiment was carried out in the open where the setup was directly exposed to sunshine free from shades of trees and buildings. The following data were collected from the solar water heater:

1. Inlet, outlet and ambient temperatures were recorded hourly with mercury thermometer between the hours of 9.00 and 16.00.
2. Volumetric water flow rate was taken with measuring cylinder and stop clock.
3. Radiation intensity using frosted dome solarimeter was read.

The averages of the data collected are shown in Table 1.

Figure 3 shows the relationship of the various temperature readings. The ambient temperature is flat bell shaped and reaches peak at 2.00 pm. The inlet temperature increases slightly during the day and follows a nearly straight line. The outlet temperature rises significantly until it peaks at 2.00 pm and then starts to reduce due to decline in solar irradiance. A peak average hot water temperature of 70$^oC$ was registered. In fact, the outlet temperature follows the radiation intensity plot in Figure 4 very closely. The radiation intensity also peaks at 2.00 pm. The collector efficiency increases slightly until 2.00 pm and thereafter it increased sharply and peaks at 92% at 4.00 pm. This may be due to the fact that the temperature of water coming to the inlet of the flat plat collector has increased slightly due to convection heat transfer in the storage tank. It can also be attributed to a sharp drop in radiation intensity.

Table 1 Average Reading of the Solar Water Heat over a Week

| **Hour** | **$T_{air}$($^o$C)** | **$T_{in}$ ($^o$ C)** | **$T_{out}$($^o$C)** | **Radiation Intensity (I) W/m2** | **Collection Efficiency ($\eta_c$)** |
|---|---|---|---|---|---|
| 9.00 | 28.4 | 28.9 | 35.8 | 126.05 | 6% |
| 10.00 | 29.6 | 30.5 | 41.6 | 176.91 | 10% |
| 11.00 | 31.1 | 32.6 | 47.8 | 210.91 | 12% |
| 12.00 | 32.6 | 34.4 | 56.4 | 233.20 | 15% |
| 13.00 | 34.1 | 36.8 | 65.6 | 258.66 | 19% |
| 14.00 | 34.8 | 38.3 | 69.9 | 280.55 | 27% |
| 15.00 | 32.9 | 39.1 | 64.5 | 228.00 | 60% |
| 16.00 | 31.3 | 39.2 | 58.6 | 198.93 | 92% |

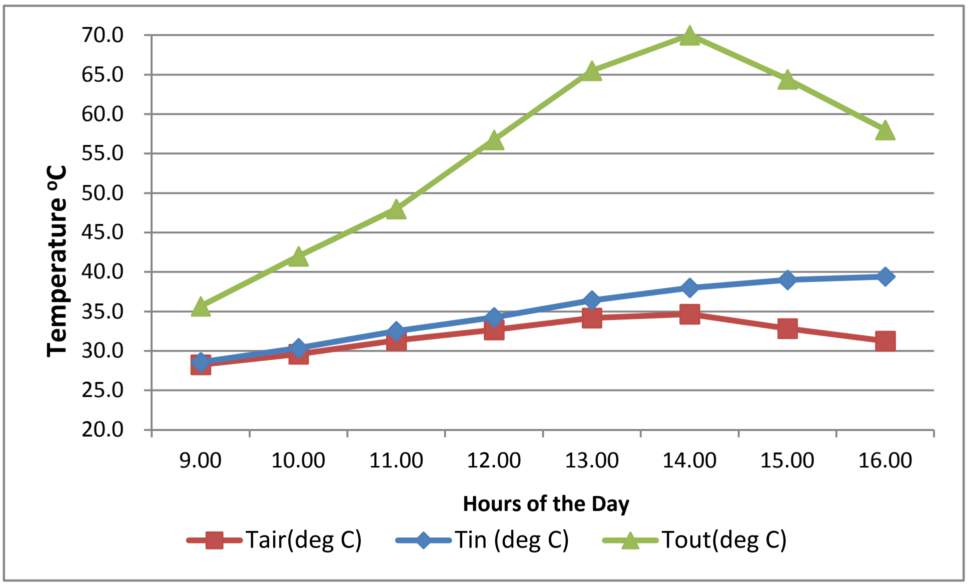


Figure 3: Plots of Ambient, Inlet and Outlet Temperatures

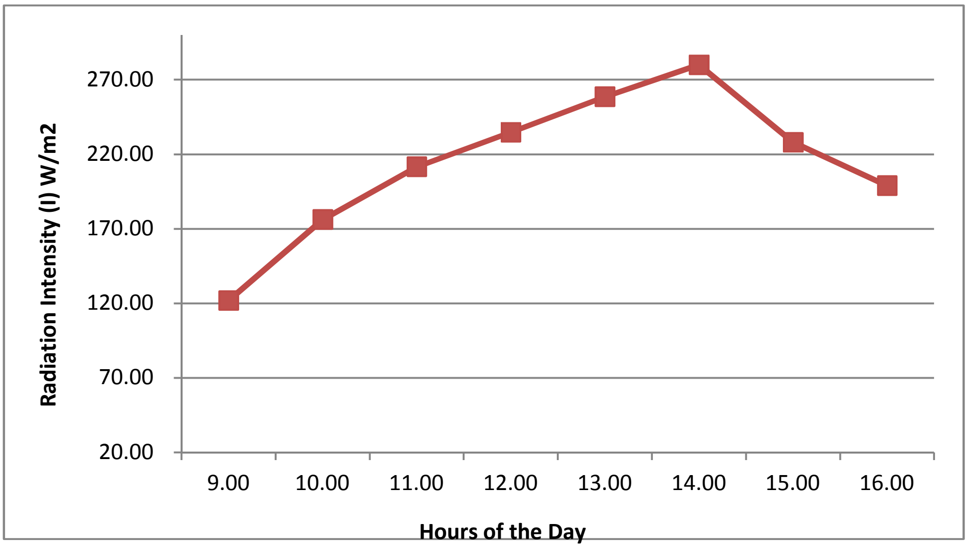


Figure 4: Plot of Average Hourly Radiation Intensity

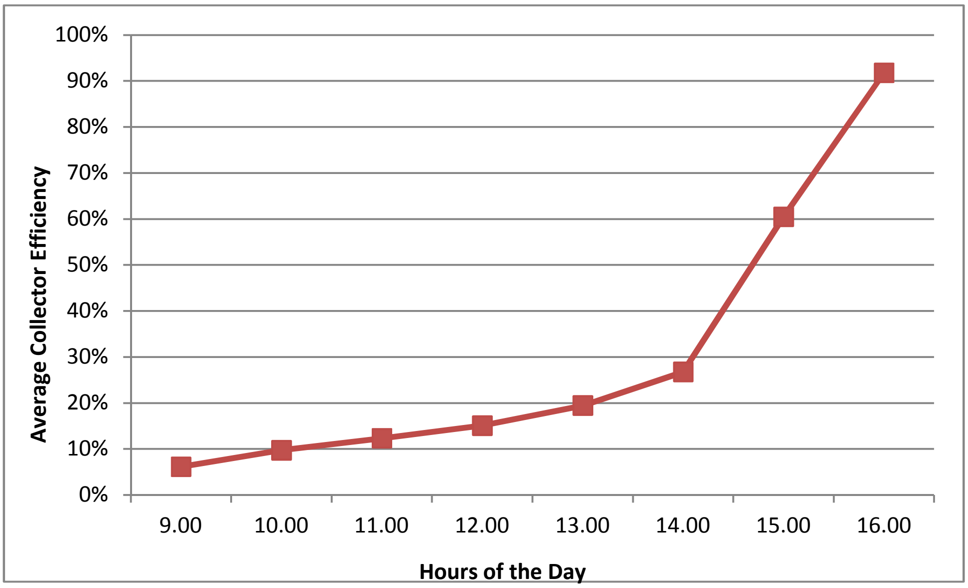


Figure 5: Plot of Average Collector Efficiency

## 5. Conclusion

A solar water heater was designed, constructed and tested in Akure, Nigeria. Hourly readings of the ambient, inlet and outlet temperatures and radiation intensity were recorded between 9.00hrs and 16.00 hrs. Between the hours of 12.00 and 4.00 pm, hot water temperatures of above 50$^{o}$C were achieved. The maximum hot water temperature recorded was 73$^{o}$C and the mean peak hot water temperature was 70$^{o}$C. Collector's mean hourly efficiency rose slight until 2.00 pm after which a sharp rise was obtained. The performance of solar water heater in Akure, South West, Nigeria shows that solar water heating is technically feasible in Nigeria and most parts of tropical Africa since insolation is similar in these regions. Since most of the hot water requirements in our society are largely below 60$^{o}$C, we have established in this paper that most of these needs can be met through solar water heating. Solar water heating can also serve as a pre-heater when temperature of more than 60$^{o}$C is needed. The need to conserve our fossil fuel has become apparent. Electricity is not available in all parts of the country and where available it is not in constant supply. Since sunshine is available everywhere in the country, solar heating is a viable option for meeting our hot water needs. Akure is located towards the southern part of Nigeria with less insolation than most parts of the South East, middle belt and the North. The fact that solar water heating is feasible in this region means that it is most likely going to be feasible and, even more efficient in all other parts of the country.

**6. References**

Bojic´, M., Kalogirou, S.A., Petronijevic´, K., (2002). "Simulation of a solar domestic water heating system using a time marching model", *Renewable Energy,* 27, 441–452.

Close, D.J., (1962). *The thermal performance of solar water heater with natural circulation*. Solar Energy 6, 33–40.

Garg, H.P., (2009), *Fundamentals of Solar Energy* available at http://www.scribd.com/doc/15698088/Fundamental-of-Solar-Energy.

Gupta, C.L., Garg, H.P., (1968). "System design in solar water heaters with natural circulation", *Solar Energy* , 12, 163–182.

Hasan, A., (1997). "Thermosyphon solar water heaters: effect of storage tank volume and configuration on efficiency". *Energy Conversion and Management*, 38, 847–854.

Hussein, H.M.S., Mohamad, M.A., El-Asfouri, A.S., (1999). "Transient investigation of a thermosyphon flat-plate solar collector". *Applied Thermal Engineering,* 19, 789–800.

Joudi, K.A., Al-Tabbakh, A.A., (1999). "Computer simulation of a two phase thermosyphon solar domestic hot water heating system". *Energy Conversion and Management,* 40, 775–793.

Kalogirou, S.A., Panteliou, S., (2000). "Thermosyphon solar domestic water heating systems: Long-term performance prediction using artificial neural networks". *Solar Energy*, 69, 163–174.

Kalogirou, S.A., Panteliou, S., Dentsoras, A., (1999). "Artificial neural networks used for the performance prediction of a thermosyphon solar water heater." *Renewable Energy,* 18, 87–99.

Kishor, N.; Das, M.K., Narain, A., and Ranjan, V.P, (2010), "Fuzzy model representation of thermosyphon solar water heating system", *Solar Energy,* 84 (2010) 948–955, available at www.sciencedirect.com.

Marshall, Glickman, "Solar Hot-Water Heaters: Green and Hot $H_2O$, Green Living", *A practical journal for Friends of the Environment*, 2009 available at: http://www.greenlivingjournal.com/page.php?p=1000003

Meinel, A.B. and M.P. Meinel, 1976, *Applied Solar Energy, An Introduction*. Addision-Wesley Series in Physics, MA, USA.

Morrison, G.L., Ranatunga, D.B.J., 1980. "Transient response of thermosyphon solar collectors". *Solar Energy,* 24, 191.

Morrison, G.L., Tran, N.H., 1984. "Simulation of the long term performance of thermosyphon solar water heaters", *Solar Energy* 33, 515–526.

Ong, K.S., 1974. "A finite-difference method to evaluate the thermal performance of a solar water heater". *Solar Energy*, 16, 137–147.

Prapas, D.E., 1995. "Improving the actual performance of thermosyphon solar water heaters", *Renewable Energy*, 6, 399–406.

Renewable Energy World, *Ambitious Solar Plan Unveiled by India*, (2009), http://www.renewableenergyworld.com/rea/news/article/2009/11/ambitious-solar-plans-unveiled-by-india accessed Jan 2012

Revees Journal Staff, "Going Solar", *Revees Journal of Plumbing, Cooling and Heating,* 2009, available online at http://www.reevesjournal.com/CDA/Articles/Feature_Article/BNP_GUID_9--2006_A_10000000000000545205

Solar Power Talk, "Can I use solar panel to heat water in my home?", (2009), http://www.solarpowertalk.com/can-i-use-solar-panels-to-heat-the-water-in-my-house

Szokolay, V., 1975, Solar Energy and Building, Elsevier Science and Technology, Architectural Press, London and USA.

Twiddle, J.W. and Weir, A.D. (1986). *Renewable energy resources*. Chapman and Hall, London, New York, Tokyo Melbourne and Madras.

Za´rate, L.E., Pereira, E.M.D., Oliveira, L.A.R., Gil, V.P., Santos, T.R.A., Nogueira, B.M., Rodrigues, M.A., 2006. "Representation of a thermosiphon system via neural networks considering installation parameters", In: *Proceedings of the 1st IEEE International Conference on Engineering of Intelligent Systems (ICEIS)*, Islamabad, 1, 1–6.

Za´rate, L.E., Pereira, E.M.D., Silva, J.P., Vimieiro, R., Pires, S., Diniz, A.S.C., 2003. "Representation of a solar collector via artificial neural networks", In: *Proceedings of the 3rd IASTED International Conference on Artificial Intelligence and Applications*, Benalmadena, Spain, pp. 517–522.

Za´rate, L.E., Pereira, E.M.D., Silva, J.P., Vimieiro, R., Pires, S., Diniz, A.S.C., 2003. "Representation of a solar collector via artificial neural networks", In: *Proceedings of the 3rd IASTED International Conference on Artificial Intelligence and Applications,* Benalmadena, Spain, pp. 517–522.

Zvirin, Y., Shitzer, A., Grossman, G., 1977. "The natural circulation solar heater-models with linear and nonlinear temperature distributions", *International Journal of Heat & Mass Transfer*, 20, 997–999.

This academic article was published by The International Institute for Science, Technology and Education (IISTE). The IISTE is a pioneer in the Open Access Publishing service based in the U.S. and Europe. The aim of the institute is Accelerating Global Knowledge Sharing.

More information about the publisher can be found in the IISTE's homepage:
http://www.iiste.org

**CALL FOR PAPERS**

The IISTE is currently hosting more than 30 peer-reviewed academic journals and collaborating with academic institutions around the world. There's no deadline for submission. **Prospective authors of IISTE journals can find the submission instruction on the following page:** http://www.iiste.org/Journals/

The IISTE editorial team promises to the review and publish all the qualified submissions in a **fast** manner. All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Printed version of the journals is also available upon request of readers and authors.

**IISTE Knowledge Sharing Partners**

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar