Thermal Performance Evaluation of a Flat-Plate Hybrid Photovoltaic-Tharmal Air Collector in South-East Nigeria

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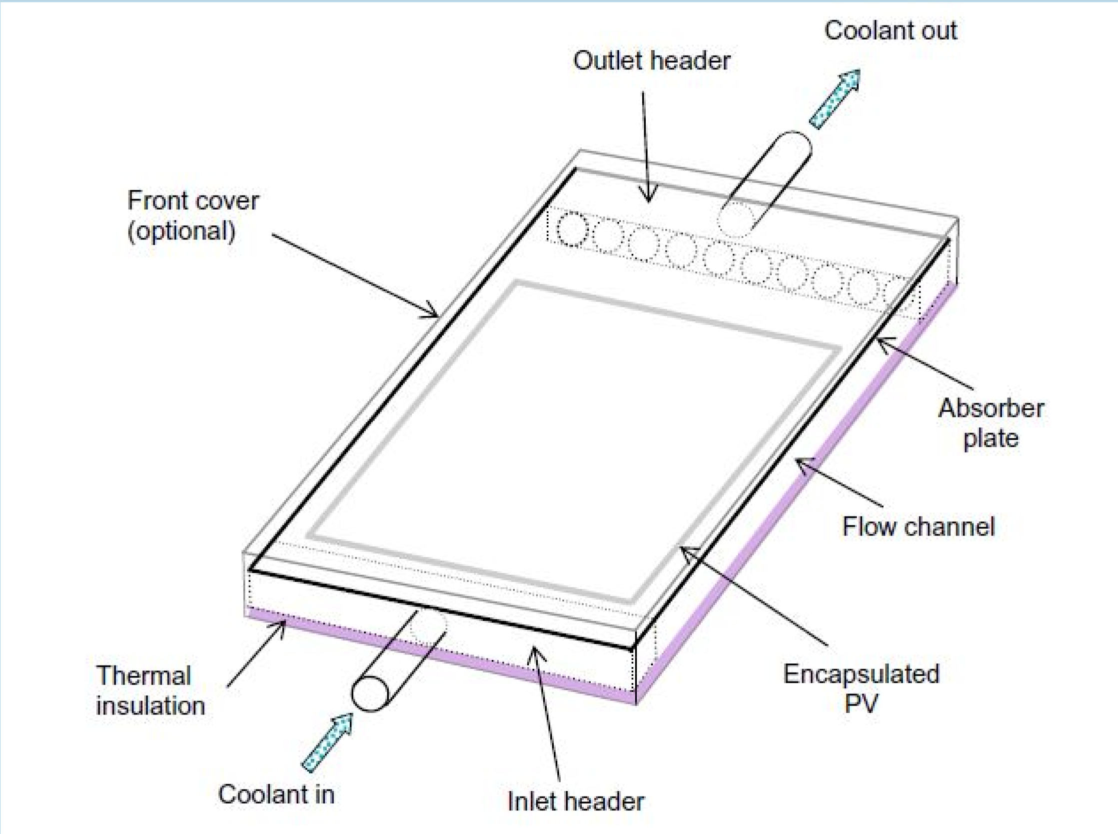
Background

The Sun is the central resource for generating all kinds of renewable energies and it controls the climatic conditions of the earth. Renewable energy technologies are considered as clean sources of energy. In order to alleviate the effect of the aforementioned situation, the Sustainable Development Goal (SDG) 7 stated that every country must ensure access to affordable, reliable, sustainable and modern energy for all. Between 1990 and 2010, the number of people globally with access to electricity has increased by 1.7 billion [1]. This poster aimed at energy-efficient technologies that uses solar energy resource to achieve the UN guidelines on agenda 2030 [2].

PVT Collector



Model Equations

$$Q_u = \dot{m} c_p (T_8 - T_1) \quad (1)$$

but $\dot{m}$ was calculated using eqn. (2).

$$\dot{m} = \rho \times A_{ex} \times V_{out} \quad (2)$$

$$Q_u = A_c F_R [G_T(\tau\alpha) - U_L(T_i - T_a)] \quad (3)$$

$$\eta_t = \frac{\dot{m} c_p (T_{out} - T_{in})}{A_c G_T} \quad (4)$$

$$\eta_{\mathbf{cth}} = \frac{\sum_{i=1}^{m} (\mathbf{Q_u})_i}{\mathbf{A_c} \sum_{j=1}^{m} (\mathbf{G_T})_j} \quad (5)$$

References

[1]The United Nations Development Programme (UNDP), "Sustainable Development Goals," 2015.

[2]United Nations, "Transforming the World: The 2030 Agenda for Sustainable Development," United Nations, New York, 2015.

[3]Renewable Energy Policy Network for 21st Century, "Renewables 2017 Global Status Report," REN21 Secretariate, Paris, 2017.

[4]International Energy Agency, "World Energy Outlook 2019," IEA Publications, 2019.

Acknowledgements

My sincere acknowledgments to my two supervisors and my sponsors DAAD for their contributions that led to the success of this research project. I shall not forget to appreciate my colleagues; Jacob, Evans, Andrew, Stephen and Emmanuel. I also wish to say kudos to my super-loving siblings Frank, Sedem, Eyram and Kekeli for their constant call and encouragements.

Instantaneous Efficiencies and Thermal Characterization

The instantaneous thermal efficiencies cannot be used to clearly depict performances of air collector under different scenarios considered in this study. However, the cumulative thermal efficiency (CTEF) was used to differentiate between how various forced convection scenarios affect the thermal efficiency. Figure 8hows the cumulative thermal efficiency plots for all three scenarios with Scenario I having the highest value of 0.5. It is followed by scenario II and III with CTEF of 0.29 and 0.18 respectively.

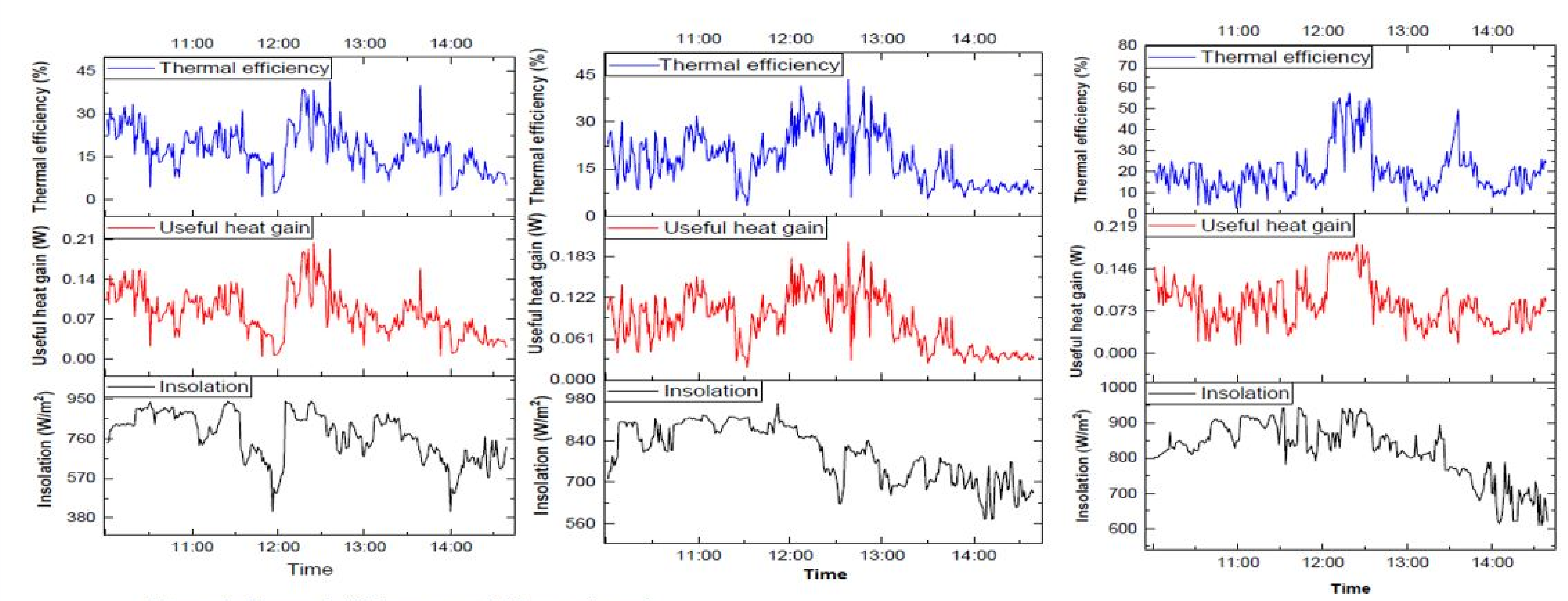
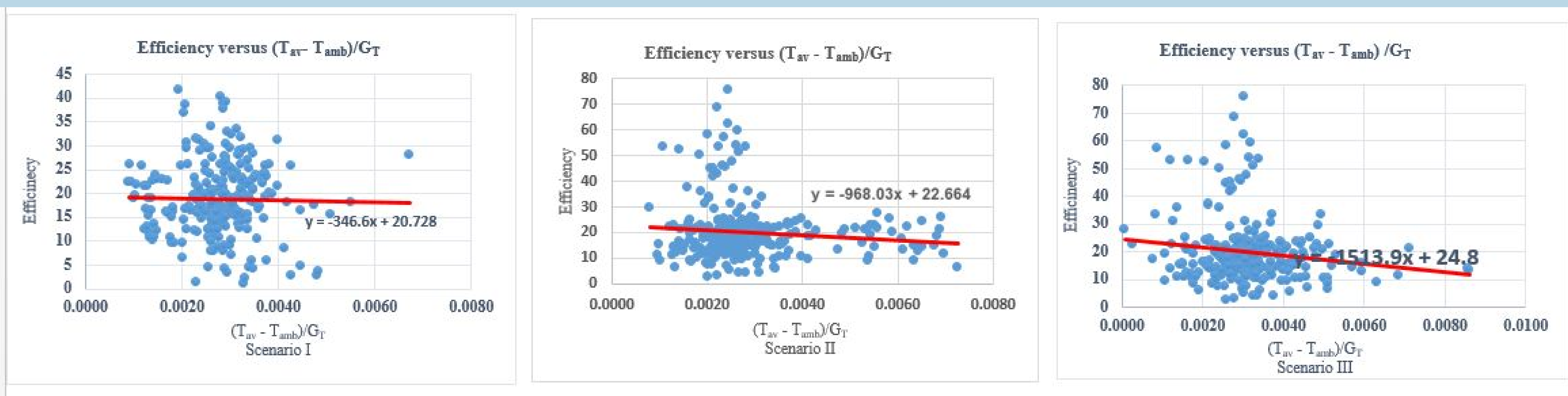


Figure 5: Thermal efficiency, useful heat gain and insolation for Scenario I, II and III.

The thermal test data conversion was developed by researchers as model that can be used to predict thermal performances of thermal systems. The intercept on y-axis gives the value of value of factor $FR_{\tau\alpha}$ and slope of the lines represent the value of $FR.UL$. From the scatter plots, the $FR_{\tau\alpha}$ and $FR.UL$ for the three scenarios have been shown on the equations of the lines of best fit. Further extension of the lines on either side will lead to intercept on Y and X axes. The intercept of the line on the y-axis is called as optical efficiency or maximum efficiency point. Scenarios I, II and III had optical efficiencies of 0.21, 0.23 and 0.25 respectively.



Thermal efficiency against reduced temperature parameter for Scenario I, II and III.

Infrared Thermal Images from Experiment

Thermal images for the absorber were also take from the start of the experiment on a typical sunny day. This infrared analysis was not done for the separate scenarios under consideration. The observed absorber temperature increase is not only a factor of level of radiation but also the accumulation of temperature and warm surrounding. The absorber temperature from the time period of 13:00-14:00 recorded an absorber temperature of 86^{o}C. Furthermore, the absorber temperature variation could also be affected by prevailing wind conditions. The other smaller temperatures record at the edge of the absorber shows the temperature of the insulating material that was exposed to radiation. It was expected to record the least temperature in all cases since neither absorb nor conduct heat.