Assessment Of The Viability Of Kaduna City Climate For Year Round Use Of Direct Solar Thermal Cooking Fuel In Housing

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Abstract: Solar energy, obtained from the sun, is the world most abundant and cheapest source of energy as a cooking fuel. It comes in two forms: Concentrated Solar Thermal, direct conversion of solar energy to heat that cooks and Solar Photovoltaic (PV) a conversion of solar energy to electrical then to heat energy, the former technology is simple and far cheaper. Despite all these architectural and engineering researches is yet to capture it for indoor cooking because of inability to cook year round due the claimed hindrances by weather condition such as clouds, rainfall, wind, dusty atmosphere and many others. This paper attempted to look into the possibility of cooking year round in Kaduna city. It collected and analyzed ten years climatic data from three different meteorological stations strategically located round the city; this showed a low solar radiation in the month of August. It further compared the result with a literature review of solar cooking carried in the same month, the findings showed at the peak of each weather hindrance a another element overrides it to give enough minimum energy for cooking a meal(s). This paper has therefore pointed the potentials of Kaduna city climate for year round use of concentrated solar thermal as a cooking fuel in residential building and further recommends the architectural collaboration with engineers for the direct capturing of solar rays into residential dwelling as a sustainable cooking fuel.

Keywords: architecture, Climatic, Cooking Fuels, housing, Kaduna City, Solar Thermals, weather.

1 INTRODUCTION

Kaduna is located at Latitudes 31' 23N, Longitudes 26' 25E (latitude 10.5231N and longitude 7.4403E) The city is presently the administrative capital of Kaduna State (one of the 36 States of the Federal Republic of Nigeria). It had been an administrative capital since the pre-independent colonial era as the administrative capital of the old Northern Protectorate in 1931 and later the Northern Region even after independence, it has grown to nineteen states yet the city still plays such role, this gives it a lot of potential to attract people from other cites therefore it becomes one of the fast growing in population and demand for infrastructure is great [1], [2]. The growing population cannot depend on the inadequacy supply and irregular distribution of electricity experience in the country. The demand for other available and cheap alternatives cooking fuels increased the dependency on non sustainable cooking fuels [3], [6], [5]. In Nigeria the demand for fuel wood is very high because more than 80% of households use fuel wood for their cooking, making it the most used form of cooking energy. The over-dependence on fuel wood attributed to its availability and affordability compared to the other sources of energy [6].

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The growing population source of cooking fuel has health and environmental hazards, therefore, a more sustainable, available and cheap cooking fuel is needed to sustain the Kaduna type of family that is large and poor [7] Solar energy as a cooking source is the most sustainable especially within the latitudes of 30^0 N and 30^0 S Kaduna City is within these latitudes where sunshine is received more than nine hours a day and solar radiation at 1kw per meter squire [8]. The abundance sunshine in this region is a good source of thermal energy as a cooking fuel [9] Thermal energy as a cooking fuel is used in two forms; Solar Photovoltaic (PV) collection of solar energy through panels which is requires an inverter to convert it to heat and light energy, this can be expensive to buy and maintained with the family income of an average northerner. Concentrated Solar Thermal CST, direct conversion of solar energy to heat energy that cooks, this is a simple technology that requires just a simple reflective surface that reflects solar energy to a black pot. Despite abundance sunshine and simplicity of technology the use of direct concentrated solar thermal is not popular and has not been given proper attention due to cultural and weather hindrances. The most hindrance is the in ability to trap solar energy for cooking throughout the year due to different in seasons with the climatic element impacts such as precipitation, clouds, high wind and dust [10], [11). This paper scrutinizes Kaduna city's ability to use direct concentrated solar thermals throughout the year through two objectives.

2 OBJECTIVES

The objectives of this paper are:

1. To find the impact of the climatic elements on solar radiation in Kaduna city
2. To find if the hour if sunshine at the lowest period(s) can give enough radiation to solar cook

3 METHADOLOGY

1. A literature review of the climatic data of Kaduna is carried out; by collecting data from three different metrological stations (Kaduna Airport Metrological Station, Kaduna State Water Board). To find the impact of the climatic elements on solar radiation.
2. A literature review the result solar cooking with a solar box cooker is be compared with sunshine and radiation of the lowest period(s)

4 FINDINGS /RESULTS

4.1 Objective 1. To Find the Impact of the Climatic Elements on Solar Radiation

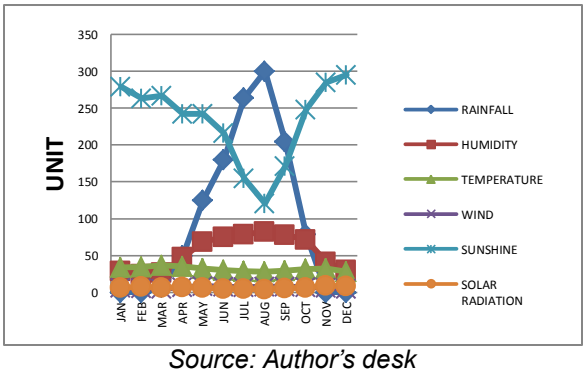
The climatic element was collected from three different stations in Kaduna the mean of each was found. The table below shows the findings.

TABLE 1: *AVERAGE MONTHLY CLIMATIC DATA OF KADUNA CITY FOR THE PERIOD OF 2007 -2016*

MONTH	RAINFALL MM	HUMIDITY	TEMT ^{0}C	WIND M/S	SUNSHINE HR	SOLAR RADITON W/m2).
JAN	0.0	28.8	34.3	6.8	9.00	6.4
FEB	0.0	24.4	34.7	5.6	9.00	8..1
MAR	7.7	26.7	36.9	5.3	8.60	7.0
APR	50	47.5	35.7	7.3	8.06	7.4
MAY	125.4	69.1	33.0	8.7	7.80	6.5
JUN	179.8	75.2	30.6	8.0	7.20	5.4
JUL	263.5	78.7	29.2	7.1	5.00	5.1
AUG	299.7	82.3	28.4	7.9	3.90	4.44
SEP	204.6	78.1	30.0	7.9	5.70	5.6
OCT	78.6	71.7	31.6	7.1	8.00	7.0
NOV	0.0	41.1	33.0	6.3	9.50	9.5
DEC	0.0	30.3	28.6	5.5	9.50	8.5

Source: Authors' summary

FIGURE 1: *RELATIONSHIP OF CLIMATIC ELEMENTS*



Source: Author's desk

Table 1 and Fig 1 show the relationships between the various climatic elements and the impact they have on solar thermals energy as a cooking fuel, this finding shows: The data from table (1) and fig (1) shows the average month climatic elements of January to December The months of January, February, November and December receive the highest hourly sunshine and solar radiation, this is due to the absence of rainfall and low humidity, it creates a clear weather for more than 9 hours sunshine and 8.5 W/m^2 solar radiations this create enabling weather for solar cooking.

The months of March, April, May, June and October receive the highest temperature with minimum rainfall, solar cooking can be effective but the presence of clouds and rainfall can break the continuity of cooking which might increase the average time needed for cooking a meal The months of June, July, Sept, October and August have high rainfall resulting to a low solar radiation. These have adverse effect on the amount of sunshine and solar radiation received for solar cooking, however, the amount of solar ration received can still be experienced up to a minimum of 4.44/m^2 a day. The month of August is the most critical month receives the highest hindrance, the following factors are observed to affect the daily and mean monthly sunshine which in turned affects the amount of solar radiation received for the month: the highest amount of rainfall (299.7mm) of the year, the highest humidity (83), the lowest temperature (28.4 ^{0}C), a wind speed (7.9m/s) that is lower than the highest 8.7 m/s in May and higher than the lowest in March (5.3m/s).

4.2 Objective 2: To find the possibility of using solar thermals during the lowest period(s) solar radiation.

The period with the likely hindrance of cooking is the month of August from Table 1 and Figure 1. Table 2 shows the lowest (3.9hrs) sunshine receive during this period

TABLE 2: *MEAN DAILY SUNSHINE*

Month	J	F	M	A	M	J	J	A	S	O	N	D
SUNSHINE HR	**9.0**	**9.3**	**8.6**	**8.1**	**7.8**	**7.2**	**5.0**	**3.9**	**5.7**	**8.0**	**9.5**	**9.5**

Figure 2:

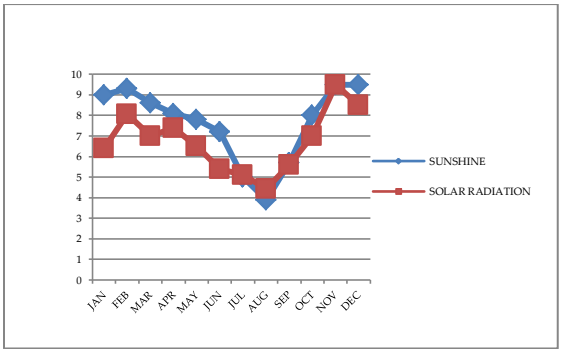


Figure 2 shows the relationship between sunshine and solar radiation received from the January to December, the

sunshine is above or equal to the solar radiation with exception of July, august and early September. These three months show the solar radiation received is more than the daily sunshine.

5 DISCUSION

The climatic data shows enough hourly sunshine needed for cooking as previously experimented by Boumann [12] which results gave for indomie, boil rice, beans respectively for a reasonable solar radiation and for successful cooking in Table 3 From table 1 and fig 1 the following factors were observed to affect the daily and mean monthly sunshine which in turned affect the amount of solar radiation received for monthly cooking, however an average sunshine of 3.9 hours and 4.44 W/m^2 is received daily.

Table 3: *AVERAGE SUNSHINE NEEDED FOR COOKING MEALS IN THE MANTH OF AUGUST*

S/N	MEAL	HOURS OF SUNSHINE
1	BOIL EGG	30- min
2	INDOMIE	45min – 1hour
3	BOIL YAM	1hour - 1hr 30min
4	BOIL RICE	1,5hr – 2hrs
5	BREAN (HARD)	2hrs – 3hrs

Source: Bouman [12]

Fig 3 shows the minimum hours needed to solar cook some selected meals as experiment by the Author for the month of August. The hourly sunshine needed to cook hard beans in the month of August is 2.5 - 3 hours far below the average sunshine received this implies sunshine received in August contains enough radiation to solar cook.

6 CONCLUSIONS

The climatic elements of Kaduna such as rainfall, humidity, wind have impact on sunshine and solar radiation not to the extent of hindering the use of solar thermals as a cooking fuel. The lowest solar radiation (4.4kw/m^2) and sunshine (3.9hr/day) received in the month of August can conveniently cook hard beans that requires about 3hours sunshine or more. This is likely to take a whole day from 6:00 to 6: am, however the ability to cook two meals throughout the year can be possible if they meals can be stuck piled, the position cooking fuel is incorporated indoors or the capacity is optimized. It is evident from the above discussion that the year round use of concentrated solar thermals as a cooking fuel in Kaduna city housing is practically possible.

7 RECOMMENDATIONS

This paper therefore recommends the following:

1. Architectural design can enhance the performance of this cooking fuel by capturing it indoors where it can be free of weather interference.
2. Architects and Engineers should collaborate to select and use material that will optimize the minimum hour of sunshine received
3. Dissemination of information on use of solar thermal energy as a cooking fuel in Kaduna city should be carried out by the state government and Non Governmental Organisation for the use of solar thermals energy

8 REFERENCES

[1] Abdullahi, Jamila, Shaibu-Imodagbe, Egbenya Musah ,Mohammed Fatima, Sa'id Aliyu, Idris, Usman Dahiru 2009 Rural – Urban Migration of the Nigerian Work Populace and Climate Change Effects on Food Supply: A Case Study of Kaduna City in Northern Nigeria. Fifth Urban Symposium 2009

[2] Wikipedia, 2009. Kaduna. http//:en.wikipedia.org.kaduna (5-3-22009).

[3] Babatunde, M.A.; Shuaibu, 2009 M.I. The Demand for Residential Electricity in Nigeria: A Bound Testing Approach. In proceedings of Second International Workshop on Empirical Methods in Energy Economics, University of Alberta, Edmonton, AB, Canada, 28–29 August 2009.

[4] International Energy Agency IEA . Energy Balances for Nigeria. Available online: retrieved 20th April 2017 http://www.iea.org/

[5] Kaduna electric (2017) Unreliable and Costly Access to Energy hampers Industrialisation reliable energy, Endless possibilities www. kadunaelectric.com

[6] Sambo, A.S. Strategic Developments in Renewable Energy in Nigeria. International Association of Energy Economics. Third Quarter 2009, pp. 15–19.: http://www.iaee.org/en/publications/newsletterdl.aspx?id=75 (accessed on 16 March 2017).

[7] Ali I. Naibbi Richard G. Healey 2013 Northern Nigeria's Dependence on Fuel wood: Insights from Nationwide Cooking Fuel Distribution Data International Journal of Humanities and Social Science Vol. 3 No. 17; p160-173 September 2013 University of Portsmouth Department of Geography Buckingham Building Lion Terrace, Portsmouth PO1 3HE, United Kingdom

[8] Hassan and M. Onimisi Y. (2012) Assessment of the Global Solar Energy Potential at Nigerian Defence Academy (NDA) Permanent Site Afaka Kaduna, Nigeria American Chemical Science Journal, ISSN: 2249-0205, Vol.: 3, Issue. 3 (July-September

[9] Solar cookers International net 2016 solar cooking frequently-asked questions webmaster@solarcooking.org

[10] Paul Denholm 2010 The Value of Concentrating Solar Power and Thermal Energy Storage Technical Report NREL-TP-6A2-45833 Ramteen Sioshansi The Ohio State University Columbus, Ohio National Renewable Energy Laboratory Golden, Colorado

[11] Bounann Ephraim Sule & Juliet Azuka Obaje (2006) Teaching and Training Student of Architecture the Production and Promotion of Solar Cookers. National Science and Technology Forum, CST Seminar Committee: 29th October.-2nd November 2007Solar cookers International net 2016 solar cooking frequently-asked questions webmaster@solarcooking.org

[12] Boumann Ephraim Sule (2014): The Effectiveness Of Practical Instructional Guide For Building Climatology in Department Of Architecture Kaduna Polytechnic Environmental Journal, The College Of Environmental Studies Kaduna Polytechnic December 2014.