THE EFFECT OF ENVIRONMENTAL LAYOUT ON DEGREE-DAYS

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ABSTRACT

Degree-day is an energy term and is defined as one-sided sum of positive differences between a certain base temperature and the ambient temperature of the environment. This can either be heating or cooling degree-days. The heating degree days are used as a basis for heating space design while the cooling degree-days as a basis for air conditioning design. This paper looks at the effect of environmental layout of a 'system' such as a building will have on the degree-days and this in effect will affect the energy required to heat or cool a space. The data used are collected in a farm house at Ilorin where the house is surrounded by 'tick' trees. The data analysed and compared with existing inference, reflects that a good and simple layout rather than aesthetic layout will be conducive even at the period of harsh climatic condition. Base temperatures of 18^{o}C for cooling degree-day calculation for a particular day gives 4.64 and 4.4 for outside fence and inside fence respectively implying that the energy required is less when we have the trees around providing shades as cooling effect, hence a good way to alleviate climatic problems if well layout.

INTRODUCTION

Meteorology is the study of whether and climate (Chambers Dictionary, 1992).

Sorinmade quoted in his work (Walter (1955)) that meteorology is the science of air treatment and its analysis. This deals with effects of air and climates across the globe. In meteorology, measurements cannot be repeated in exactly the same way, that is, a measurement cannot be repeated as it can be done in other area of science.

Definitions of Terms of Degree-day,

Cooling Degree-day, Heating Degree-day and Base temperature are important to this study analysis:

Degree-day – is a concept used in quantifying the deviation in the severity of hotness or coldness of a climate (Sorinmade, 2002). This is an important climatic statistics useful in estimation of energy needed for cooling or heating a space during a period of time. Therefore degree-day is the accumulation of one-sided differences between a certain base temperature and the different dry-bulb temperature obtained hourly.

Cooling Degree-day – this is the summation of all positive difference between different hourly dry-bulb temperature and the base temperature.

Heating Degree-day – is the summation of all positive difference between the base temperature and the set of ambient temperature.

Base temperature – this is desired temperature of the cooling of heating space.

The theme of this year National Engineering Conference and the Annual General Meeting of this great Society of Nigerian Engineers titled *'Engineering response in combating the effect of climate change in Africa'* is timely. With no cause there cannot be effect; hence the question now is that what causes the climatic change in the World Africa inclusive? Climate change and global warming are Siamese twins' which are difficult to separate. An International group of Scientists, inter governmental

panel on Climate change (IPCC) identified human activities as the primary cause of global warming. These human activities include emission of greenhouse gases and aerosols which in a way affect the climate, depletion of the stratospheric ozone layer, burning of fossil fuel and biomass burning; these sources are linked to degradation of air quality and deposition of acid. Another human activity is deforestation which is rampant in Africa: fell trees are used as fire wood causing double effect; dead plants don't absorb carbon dioxide (green house gas) and combustion process emits more of green house gases.

Deforestation is rampant especially in the part of Oyo-North of Nigerian where trees are fallen to use as charcoal. The falling of trees has a negative effect on the climate; the conversion of the fell tree to charcoal emits carbon dioxide, the final use of charcoal as fuel emits carbon dioxide. This is very dangerous to our climate.

Meteorologist tends to gather, store and analyse data in order to forecast and advice. Certain work have been carried out in analyzing data for certain cities in Nigeria, Olorunmaiye and Ariyo worked to relate cooling Degree-days and base temperature for Southern Nigeria Cities and came up with an empirical equation, Sorinmade worked on statistical analysis of weather data for Katsina for Refrigeration and Air-conditioning, he concluded that it is cheaper to operate a cooling space from November to January and energy consumption for heating space is less in April. Raheem built up on the work of Olorunmaiye and Ariyo to compute the heating degree-days for Ikeja and ilorin and reported that the design month for heating device for Ilorin and ikeja are July and August and August which means it is period of highest heating degree-day.

In this paper the weather data were collected for a period of 30-day at Ilorin.

The data include dry bulb temperature, wet bulb temperature and relative humidity which is the climatic factors that make the degree of hotness and coldness vary from region to region throughout the entire world. The main objective of this paper is to analyse the

data collected for this period based on heating and cooling degree-days using the base temperatures of 37°C, 40°C and 18°C, 22°C for heating and cooling degree-days respectively and compared the effect the layout has on the data analysed.

METHODOLOGY

Data Collection

The instrument used for the data collection is Temperature-Humidity Meter; it is made by FLUKE Corporation, Taiwan, model FLUKE 971. It measures dry bulb, wet bulb temperatures and RH at the same time. It is digitally displayed and can easily be recalled. It has the following specification:

Temperature range: 20°C - 60°C,
RH range: 5% - 95% RH
Accuracy: Temperature ± 0.5°C, RH ± 2.5% RH @ 25°C, Revolution 0.1°C

The data were collected at **'NEFRADAY'** Farm Ltd at Ilorin, Kwara State. There is a building which housed the incubator for the farm, the building is enclosed or fenced with rows of 'tick' trees figure 1. The distance between the wall of the building and the rows of the trees is about 6100 mm. The two readings of the ambient temperature were taken; one at the space between the building wall and the row of the trees and this designated as T_{a1} while the second set of readings were taken at the open end of the row of trees and this is termed T_{a2}. The data were taken hourly on the average of 10 hours (8 am – 6 pm) daily for the period of 30-day.

RESULTS

The data collected for the period were analysed based on the following formulae for degree-days:

Calculation of Degree-days

Cooling Degree-day is computed using the equation thus:

$$D_C = \sum_{t}^{m} f(Ti)\frac{1}{24} \quad (1)$$

Where $f(T_i) = T_i - T_b$ (2)

If $T_i > T_b$ And $f(T_i) = 0$

If $T_i \leq T_b$ (3)

Heating Degree-day is computed from hourly dry bulb temperature using the equation thus:

$$D_H = \sum_{\iota}^{m} f(Ti)\frac{1}{24} \quad (4)$$

Where $f(T_i) = T_b - T_i$

If $T_b > T_i$ (5)

And $f(T_i) = 0$ If $T_i \geq T_b$ (6)

The results obtained for cooling Degree-days and heating Degree-days for base temperatures of 18°C, 22°C and 37°C, 40°C respectively for the hours of data collection of the 30-day period are as in Tables 1. Equally the graphs obtained are as in figures 2, 3 and figures 4, 5 for the cooling degree days of base temperatures of 18°C, 22°C and heating degree days of base temperatures of 37°C, 40°C respectively.

DISCUSSIONS OF THE RESULTS

The data obtained for the 30-day period are considered and used to compute the cooling and heating degree-days based on two different base temperatures of 18°C, 22°C and 37°C, 40°C. The results obtained as in the figures 2 and 3 show that for cooling degree-days obtained with the data of the outside fence are higher than those obtained in-between the 'fence' and the building, which implies that to refrigerate the building there will be a reduction of energy consumed compared to when the building is not surrounded with trees. On days 16 and 27 there is slightly higher cooling degree-day for in-between the building and the 'fence' this is because an hourly ambient temperature of this space is higher than the base temperature which make that hour component of the degree-day to be zero. And on the results of the heating degree-days as in figures 4 and 5 there is higher values of this in-between the building and the 'fence' and this implies that more energy will be required to heat a space as such building, however an incubator that need to be heated to hatch eggs still need such a layout in spite of higher energy that may be required for draught is avoided against the eggs. On day 8 there is higher heating degree-days in the outside fence this is because an hourly reading was not taken for there was rain and that of outside building was taken. The trees have dual purpose of reduction of the effect of the 'harsh' climatic condition and absorbing the

emitted greenhouse gases in our environment.

CONCLUSIONS

Having gathered the data and calculate the cooling and heating degree-day with reference to two locations and two base temperatures for both cooling and heating degree-days, 18^{o}C, 22^{o}C and 37^{o}C, 40^{o}C respectively. It shows that the layout of the surrounding with tress does affect the degree-days and could be seen that it is of great benefit to alleviate or reduces the effect of harsh climatic condition/globalwarming and this equally will brings about the reduction of energy in cooling a space when the layout is natural and simple.

RECOMMENDATIONS

With the results obtained in the study, it is then recommended that the causes of climatic problems/globalwarming should be reduced to the minimum with the following:

i. Encouraging fencing of houses/buildings with trees that will absorbs Carbon [illegible] reduce the causes of climatic problems such a global warming.

ii. The companies that emits carbon dioxide via their production should purchase and preserve forest that absorbs carbon dioxide emissions (Microsoft Encarta, 2008)

iii. The power generation, transmission, and distribution should be improved so as to reduce the individual generation which emitt green house gases.

iv. Elimination of gas flaring in the Niger Delta Region ofNigeria.

v. Discouraging deforestation and political will tobring the culprit to book.

NOMENCLATURE

$\sum$= Summation

T_a= Ambient Temperature

T_{a1}= Ambient Temperature in-between building and 'fence'

T_{a2}= Ambient Temperature outside 'fence'

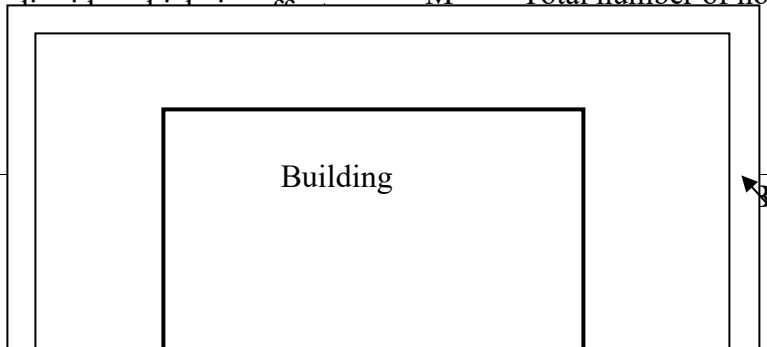
T_i = outside temperature /hour

^{o}C= Degree Centigrade

D_H= Heating Degree-day

D_C= Cooling Degree-day

M= Total number of hours



T_{a2}

Row of Tree

Figure 1: The Sketch of the site where temperatures readings were taken

Table 1: The Table of Computed Degree-day for the period

	Cooling Degree-day					**Heating Degree-day**			
	Base Teperature of 18°C		Base Teperature of 22°C			Base Teperature of 37°C		Base Teperature of 40°C	
	Out Fence Temp.	*In Fence Temp.*	*Out Fence Temp.*	*In Fence Temp.*		*Out Fence Temp.*	*In Fence Temp.*	*Out Fence Temp.*	*In Fence Temp.*
1	4.64	4.40	3.14	2.90		2.48	2.73	3.61	3.85
2	5.00	4.93	3.05	2.97		3.70	3.78	5.08	5.16
3	5.13	4.80	3.46	3.14		2.79	3.11	4.04	4.36
4	4.30	4.29	2.96	2.95		2.04	2.05	3.04	3.05
5	4.91	4.85	3.25	3.19		2.20	2.26	4.25	4.31
6	4.55	4.51	2.72	2.68		3.00	3.06	5.53	5.57
7	5.13	4.74	3.29	2.90		3.58	3.97	4.96	5.35
8	4.92	4.85	3.25	3.02		4.54	3.86	5.91	5.23
9	4.48	4.30	2.98	2.80		2.65	2.83	3.78	3.95
10	5.32	5.15	3.49	3.32		3.39	3.56	4.76	4.93
11	4.87	4.83	3.20	3.16		3.05	3.09	4.30	4.34
12	4.73	4.37	3.23	2.87		2.40	2.76	3.53	3.88
13	6.19	5.40	4.36	3.57		3.00	3.31	4.25	4.68
14	5.86	5.58	4.03	3.75		2.85	3.13	4.22	4.50
15	4.73	4.59	2.89	2.76		6.83	7.25	5.36	5.49
16	3.79	4.40	2.29	2.90		3.34	3.12	4.46	4.12
17	5.14	4.84	3.48	3.18		2.78	3.08	4.03	4.33
18	5.31	4.93	3.64	3.26		2.61	2.99	3.86	4.24
19	4.55	4.23	2.88	2.57		3.37	3.68	4.62	4.93
20	5.80	5.48	3.80	3.48		3.70	4.02	5.20	5.52
21	5.25	5.08	3.29	3.13		4.25	4.43	5.75	5.93

22	6.09	5.60	3.99	3.16		2.20	2.47	3.33	3.59
23	5.41	5.15	3.75	3.48		2.50	2.77	3.75	4.02
24	5.45	5.02	3.55	3.20		4.05	3.98	5.55	5.36
25	5.15	4.74	3.15	2.74		4.35	4.76	5.85	6.26
26	3.88	3.63	2.41	2.17		4.03	4.32	5.28	5.57
27	1.81	2.23	1.14	1.56		1.36	0.95	1.86	1.44
28	5.11	4.71	3.45	3.05		2.80	3.20	4.05	4.45
29	4.85	4.75	3.18	3.08		3.07	3.17	4.32	4.42
30	5.21	4.97	3.55	3.30		2.70	2.95	3.95	4.20

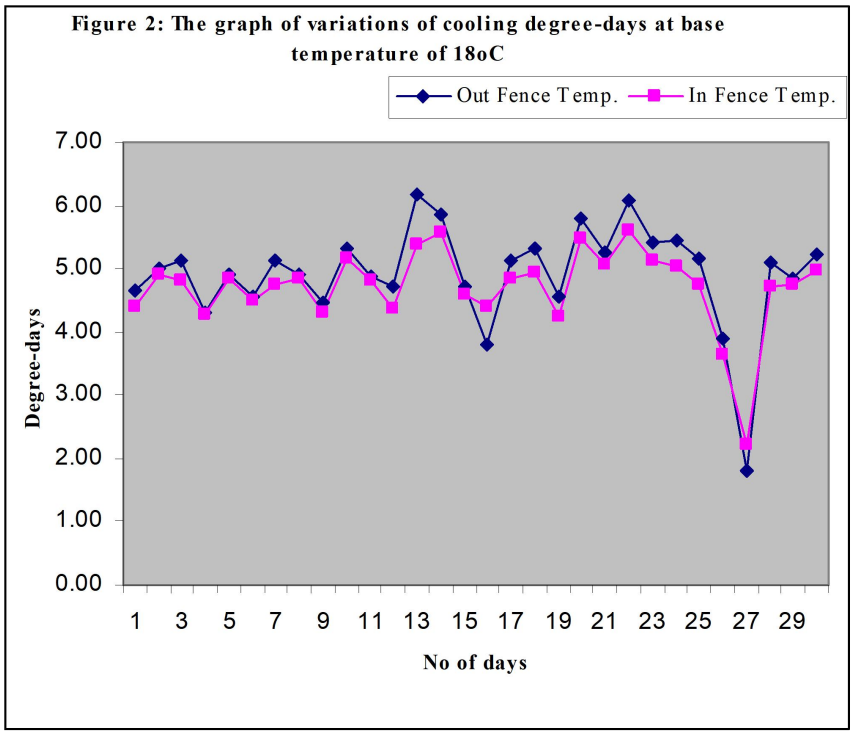


Figure 2: The graph of variations of cooling degree-days at base temperature of 18oC

Figure 3: The graph of variations of cooling degree-days at base temperature of 22oC

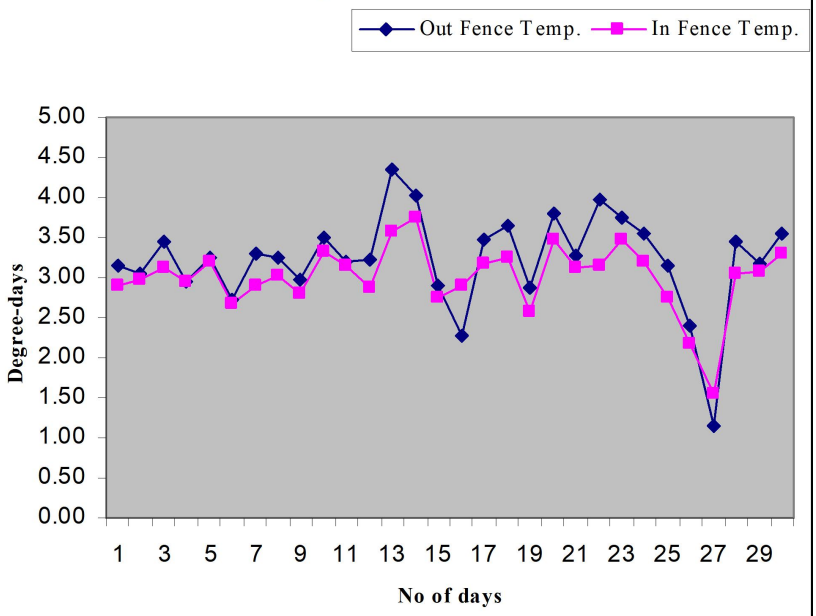
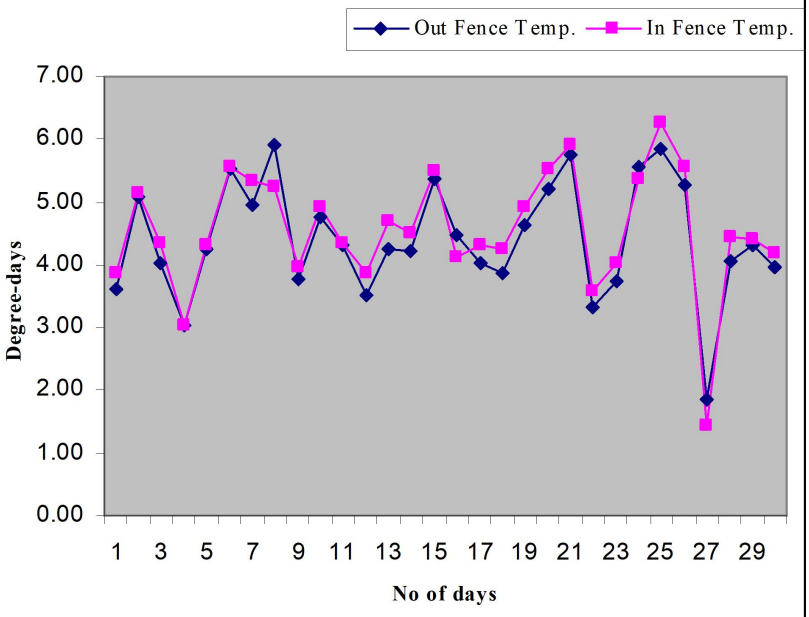


Figure 4: The garph of variations of heating degree-days at base tempertaure of 40oC



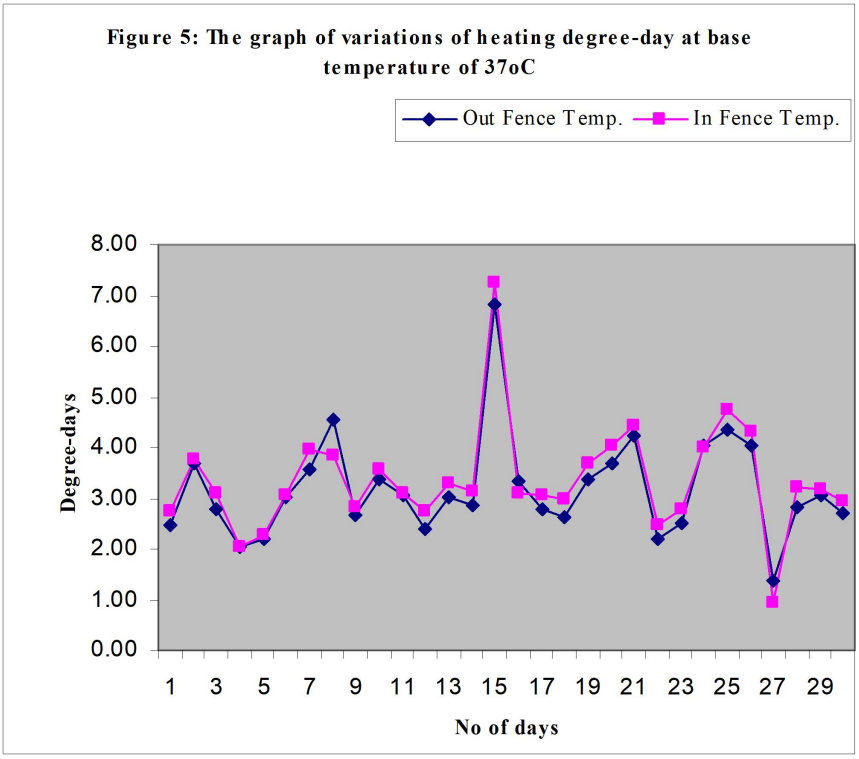


Figure 5: The graph of variations of heating degree-day at base temperature of 37oC

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