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Do Architects Design for Thermal Comfort? A Case Study of Some Houses in Lagos

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Abstract

Traditional Residential Buildings have the repute of being more thermally comfortable than modern residential buildings from previous researches conducted in the field of climatic comfort. While majority of residential buildings designed by quacks in the urban centres have no consideration for thermal comfort, even the ones designed by Architects most times do not seem to be any better. It is in view of this, that this paper makes case studies of three existing residential units designed by different Architects in order assess the thermal comfort levels. Utilizing the corrected effective temperature (CET) index, which is the most commonly used technique for assessing the degree of thermal sensation and comfort, the study lays bare the success and shortcomings of the case studies and further establishes the importance of adequate attention, in design, to such factors as proper orientation of buildings, placement and orientation of windows, careful use of shading devices and use of insulating materials.

Keywords: Thermal comfort, CET index, Residential, Lagos.

1. Introduction

The history of human settlement shows us that with accumulated human experiences and imagination, the architecture of the human shelter evolved diversely in response to the differing challenges of various locations and climates. Besides climate criteria, there are many other criteria for design, such as economics, culture, building programme, site contours, views, etc. However, a locality's climate is probably its most durably endemic characteristic (besides the site's bedrock)" – Ken Yeang (1996). As the location's most endemic factor, climate provides the designer with a legitimate starting point for architectural expression in the endeavour to design in relation to place; because climate is one of the dominant determinants of the local inhabitant's lifestyle and the landscape's ecology. Since thermal comfort is a basic desire of man, it is very important that the houses being designed and constructed by our Architects are thermally conducive. The main aim of this study is to obtain and analyse climatic thermal comfort date from three case studies of existing housing units with a view to establishing the overall thermal performance of the buildings and thereafter highlights the parameters that are significant for workable thermal design in Lagos.

2. Thermal Comfort of Buildings in Lagos

Lagos Climatic Data

Nigeria lies within 4^0N to 14^0N latitudes and $2.^0$E to 14.5^0 longitude (Fig. 1). Lagos has a latitude of approximately 6.5^0N latitude and 3.5^0E longitude and located within the warm humid climate zone (Fig. 2) The annual mean temperature usually varies between 25^0C and 27^0C. The monthly mean and daily temperatures vary and often range between 20^0C and 33^0C, while throughout the year, temperature hardly falls below 18^0C at any instance and little variation exists between day and night temperatures.

Relative humidity is usually high in the mornings and during rainy seasons ranging between 80% and 100% while it falls in the afternoons and during dry seasons between 60% and 80%. Heavy cloud and water vapour in the air act as a filter to direct solar radiation; it is thus reduced and mostly diffused – but clouds also prevent reradiation form the earth at night. There are two marked seasons: Dry Season generally holds between November and March and Wet Season (rainy) season between April and October. Rainfall is heaviest during the months of June and July.

2.1 Thermal Comfort Indices

It is universally agreed that thermal comfort is subjective. Though complete agreement may be obtained on what is thermally uncomfortable, it is unlikely that more than 60-70% of a group of people will agree that any particular situation is thermally comfortable – (Agarwal and Komolafe, 1984). Thermal Comfort Indices refers to a range or set of conditions under which thermal comfort is experienced. Thermal Comfort can also be represented by a single scale of measure and may efforts have been made to develop such scale, which include:-

Effective Temperature (ET):- Produced by Hough and Yaglou in 1923, and defined the ET as the temperature of a still, saturated atmosphere, which would, in the absence of radiation, produce the same effect as the atmosphere in question.

Corrected Effective Temperature (CET):- Whilst the ET scale integrates the effects of three variables, namely temperature, humidity and air movement. The CET scale also includes radiation effects and was developed separately by Vernon & warmer in 1932 and by Bedford in 1946. it is considered the most practical of all thermal indices and shall be utilized and discussed in details in this study.

Equivalent Warmth (EW):- The scale was developed by Bedford in England and is based on the reaction of 2000 factory workers engaged in light work, under varying indoor conditions. It takes into account the air temperature the RH and the mean radiant temperature. The EW is reliable within the comfort zone up to 35^OC with low RH and up to 30^OC with High RH. It however under estimates the cooling effect of air movement at high humidity.

Operation Temperature (OT):- Developed the USA by Winslow, Herrington and Gagge; in principle very similar to the scale of equivalent warmth and it combined the effects of radiation and air temperature.

Equatorial Comfort Index (ECI):- Was developed in Sugagore by C. G. Webb in 1960. Subjective responses of acclimatized subjects were recorded together with measurements of air temperature, humidity, and air movement – the experimentally – found relationships were organized into a formula and shown on a graph very similar to the ET monogram.

Resultant Temperature (RT):- Developed by Misseiard om France. It is considered to have a slight improvement on the ET scale and reliable for moderate climates but not for tropical conditions as it does not allow sufficiently for the cooling effects of air movement over 35^{O}C and 80% RH.

Predicted Four Hour Sweat Rate (P_4SR):- British naval authorities developed the P_4SR to consider the special heat stresses experienced by Seamen, which is indicated by the rate of sweat secretion from the body, the pulse and the internal temperature. It is considered unsuitable for temperatures below 28^{O}C and it under estimated the cooling effects of air movement at high humidities. The effects of air temperature, the humidity

Heat Stress Index (HIS):- The HIS is considered reliable between 27^{o}C and 35^{O}C, 30-80%RH, it takes the metabolic heat production of subjects doing various kinds of works as an indication of heat stress.

The Bio-climatic Chart:- Victor Olgay's conviction that there is no point in defining a single figure index, as each of the components are controllable by different means resulted in the construction of the bio-climatic chart. The comfort zone is defined in terms of the dry bulb temperature and the RH and the effects of air movements and radiation on the comfort zone are indicated.

Index of Thermal Stress (ITS):- This is the calculated cooling rate produced by sweating which would maintain the thermal balance under the given conditions as established from first principles by Givoni. It is reliable in the range of conditions between comfort and severe stress, provided that thermal equilibrium can be maintained.

Standard Effective Temperature (SET):- This is a rational physiologically based index of comfort. It expresses any environment, clothing and activity level in terms of a uniform environment standardized at 50% RH, air velocity of 0.125m/S, activity of 1 met. and intrinsic clothing at 0.6 clo.

Out of these, The Corrected Effective Temperature (CET) is still considered the most practical of the various thermal indices. This study shall utilize this index and the thermal comfort for Lagos on this scale occurs between the index of 22^{O}C and 27^{O}C and an air velocity of 0.1 and 1.5m/s.

3. Methodology and Data Collection

The Research was conducted using three existing Housing Units as Case Studies in the following areas: - Festac Town, Victoria Garden City Lekki and Unilag Akoka, A 3-Bedroom Semi-Detached building was chosen out of the various prototypes in Festac Town, another 4-Bedroom Semi-Detached Building in VGC and 4-Bedroom Terrace Housing in Unilag. Measurements were obtained in each case to determine the Corrected Effective Temperature (CET) during the same period of year (month of November, for convenience). Measurements of Dry Bulb Temperature, Wet Bulb Temperature, Globe Temperature, Relative Humidity and Wind Velocities were taken at intervals of two hours from morning till evening. The measurements were obtained for four areas of the house in each case namely:

- The public area represented by the sitting room.

- The private area represented by the bedroom.
- The service area represented by the kitchen and
- The outdoor area represented by either the carport or entrance lobby or a covered terrace.

It is noted that the case studies are in different parts of Lagos as such the comparison between them as taken this into consideration. So each study is analysed with respect to its immediate outdoor condition and the result of the corrected effective temperature (CET).

a. Instrumentation

The instruments used for the experiment are: - The Whirling Hygrometer, The Humidity Slide Rule, The Black Globe Thermometer, The Kata Thermometer, and The Stop Watch.

b. The Charts

Chart For The Computation Of Air Velocities From Readings Of The Silvered High Temperature Kata Thermometer (Cool Range 54.5 to 51.5^{O})
This chart has readings of the Kata Factor for the Kata Thermometer in use (467) at the extreme left corner. The cooling time of the Kata in seconds the cooling power in units at the centre of the monogram, air temperature in degree centigrade and air velocity in metre per second (Fig. 17).

Chart for the Estimation of Radiation from Globe Thermometer Readings: -
This chart contain five scales, scale A is the Globe Thermometer Temperature minus Air Temperature in ^{O}C, scale B is the Air Velocity in m/s, scale C is the positive and negative reading about a zero point, scale D is the Globe Temperature in ^{O}C and Scale E is the Mean Temperature of Surroundings in ^{O}C (Fig. 18).

The Psychrometric Chart Showing Normal Scale of Corrected (CET)
A Psychrometric Chart showing normal scale of Corrected Effective Temperature (CET) with lines showing values of the velocity of air in metre per second. A vertical temperature scale readings of the globe thermometer GT and those of Wet Bulb Thermometer WBT OC (Fig. 19).

The experiments as explained in details in Appendix – 1 are carried out for the spaces (Living Room, Bedroom, Kitchen and outdoor space) in all the three case studies. The same sets of instruments were used throughout the duration of the experiments for all the case studies. Also the occupants were asked to respond to questionnaires a sample of which is given in Appendix – 2, to evaluate the comfort condition. It was found that in all the cases, the assessment of the comfort level of the occupants compare favourably well with the results obtained and plotted on the psychrometric chart.

The results are presented in tables and figures below.

4. Analyses of Results/Findings

4.1 Temperature Distribution

An analysis of the results obtained from the experiments in the three study areas reveals that temperature is generally at its peak for the different spaces between 12.00 hours and 14.00 hours and is lowest in the mornings and evenings. This could be attributed largely to the natural phenomenon of the sun, the main generator of heat energy, being overhead and most intense within this period. But temperature difference (between the lowest and the highest for the day) is in no case, more than $1.5^{O}C$. This is a confirmation that the diurnal temperature in warm humid climate, which Lagos lies, is negligible.

However, although the three study areas are all within the general Lagos climatic zone and experiments conducted during the same month of same weather condition, temperature readings for respective spaces vary and are lowest for the Unilag Terrace House and highest for the Festac Town experiment. Taking the sitting room for instance, the dry bulb temperature readings for the day ranges between $29.0^{O}C$ and $31.0^{O}C$ for Unilag, $30.0^{O}C$ $31.5^{O}C$ for V.G.C, and $30.0^{O}C$ and $32.0^{O}C$ for Festac Town. This is an initial indication that the Unilag Terrace House exudes greater suitability of design use of materials in addressing the question of thermal balance.

Although, the temperature readings for the bedroom at Unilag are similar to those of the sitting room, they are higher at the other two. At VGC, the bedroom temperatures range between 30.0OC while at Festac they range between 30.5OC and 32.0OC. two important factors from observation are vital to the situation here – the use of insulating materials and shading devices. Of all the spaces covered by the experiment, only the bedrooms are located on the upper floors directly below the roof. While the Unilag Terrace House roof is well insulated, Festac Town is not, and V.G.C. hardly is with its concrete roof. Also at Unilag, the use of shading devices is natural and effective. At V.G.C., shading devices are used but in a good number of cases, they appear like an after-thought making them less successful while at Festac Town, they are virtually non-existent. Adequate attention to these two factors would have drawn the others closer to Unilag.

In all cases, temperature readings for the kitchens are expectedly higher than other spaces. (UNILAG: $30.5^{O}C$ – $32.0^{O}C$;V.G.C: $30.5^{O}C$ – $32.0^{O}C$; FESTAC: $31.0^{O}C$ – $32.0^{O}C$). This is as a result of the cooking activities that are sure to generate more heat and thereby raise temperature levels. Outdoor temperature for both V.G.C. ($29.5^{O}C$ – $31.5^{O}C$) and FESTAC TOWN ($29.5^{O}C$ – $31.0^{O}C$) are slightly lower than indoor temperatures, but for UNILAG outdoor temperatures ($29.0^{O}C$ – $31.5^{O}C$) are slightly higher than indoors and this is a significant development in that it indicates that the indoors have been well treated and on is likely to feel more comfortable than outdoors.

4.2 Relative Humidity

The distribution of Relative Humidity at FESTAC Town is such that the cooler the space the higher the Relative Humidity. The coolest space is the outdoor and has the highest Relative Humidity. The coolest space is the outdoor and has the highest Relative Humidity range of between 60% and 74%, the lowest occurring at 14000 hours and the highest at 08.00 hours. The warmest space – the kitchen – has a Relative Humidity range of between 60% and 66%. This obviously a direct consequence of the higher difference between the dry bulb temperature and the wet bulb temperature. Generally, RH for FESTAC Town is highest in the mornings and sometimes also evenings and lowest in the afternoons. The situation at V.G.C. is similar to Festac Town. The kitchen has a RH range of between 60% and 64%, lower than the bedroom (60% - 70%). The high air velocity recorded in the kitchen is also a key factor here. So also is the surrounding waterfront. At UNILAG, the Relative Humidity for the Sitting, Bedroom and outdoor space is similar ranging between 60%/62% and 80% in all cases. This is as a result of similar Temperature (dry bulb and wet bulb) readings for the spaces as noted earlier. The RH range for the kitchen (60% - 68%) is only a little lower. However better air movement (between 0.6m/sec and 0.7m/sec) at UNILAG is of great benefit in this situation for the purpose of evaporation.

General, one point that common to all three-study areas is that Relative Humidity decreases as temperature difference between wet & dry bulb temperature increases.

4.3 Wind Speed

Air Velocity through the different spaces both at V.G.C. and Festac Town vary significantly while at UNILAG, it is fairly close ranging at high points between 0.6m/sec. and 0.7m/sec. This is because windows at Unilag Terrace House are well designed and appropriately to allow for unhindered cross-ventilation.

At V.G. C, air velocity is directly related to the level of success in the design and location of windows. The bedroom is the least successful. Although two windows are located on two sides of the room, the relatively small size of the leeward side could have been responsible for the air velocity being kept at only between 0.3m/sec. and 0.4m/sec.

The sitting room is a little more successful with the figures between 0.35m/sec and 0.4m/sec. But perhaps the most successful is the kitchen. As could be observed from the location and size of the windows in the plan it is not surprising that air velocity is as high as 0.6m/sec. Outdoor air velocity is expectedly as high as between 0.6m/sec. and 0.7m/sec. Poor window design and positioning are generally big problems at FESTAC Town and it is not surprising therefore that velocity is generally low. The kitchen is worst of all. The windows are too small and, to worsen matters, are obstructed by stores and staircases. It is not surprising therefore that air velocity is never above 0.2m/sec.

This is expected to create thermal problems of the kitchen in the light of increased temperature naturally expected. The bedroom fairs only a little better. The windows on two sides of the room are so close to each other that air velocity could only range between 0.2m/sec. and 0.3m/sec. The living room, obviously better addressed, has figures up to 0.4m/sec.

In all cases, outdoor air velocity is as high as 0.6m/sec or slightly more and is expected to have significant positive effect on the thermal balance of those spaces.

4.4 Corrected Effective Temperature (CET)

Festac Town

The Corrected Effective Temperature (CET) calculation for the sitting room (Fig. 26[a]) reveals figures between 27.1^{O}C and 27.^{O}C. These are mostly slightly outside the comfort zone but clearly greater air velocity would have helped/push the figures into within the comfort zone. The CET figures for the Bedroom (Fig. 26[b]) range between 27.3^{O}C and 27.8^{O}C. All seven time-hours used fall outside the comfort zone. However, with better air velocity obtained at least some of these would have managed to ‘sneak’ in into the zone.

4.5 V. G. C

The CET figures for the sitting room range between 26.9^{O}C and 27.6^{O}C (Fig. 27[a]) keeping it almost entirely within the comfort zone. However, with figures ranging between 27.0^{O}C and 27.8^{O}C (Fig. 27b), two of the bedroom figures only managed to ‘sneak’ in but better air velocity achieved would have further helped its cause with more convenient figures.

The kitchen, with figures between 27.0^{O}C and 27.6^{O}C (Fig. 27[c]), is almost entirely on the upper limits and it is kept there only thanks to the fairly good air velocity achieved. An additional precaution of effective shading devices would have help reduce the mean radiant temperature in the first place and therefore further helped its cause. Outdoor CET, at between 26.6^{O}C and 26.9^{O}C, are within the comfort zone (Fig. 27[d]).

4.6 Unilag Terrace House

The Unilag Terrace House is clearly a very successful experiment in terms of thermal balance and performance. The Corrected Effective Temperature (CET) for all the spaces are conveniently within the comfort zone. Sitting Room (26.2^{O}C – 26.8^{O}C); Bedroom (26.2^{O}C – 26.8^{O}C) (Fig. 28[a]); Outdoor (Fig. 28[b]) (26.4^{O}C – 25.9^{O}C) and kitchen for which the highest CET was recorded was a success as this figure of 26.9^{O}C is still within the comfort zone.

The success story of the UNILAG Terrace Housing is attributable to a number of factors. These factors, which helped to keep temperature readings relatively low and fairly constant include good use of insulating materials, effectively use of shading devices thereby combating radiation, proper arrangement and design of windows for effective cross-ventilation and high air velocity. Finally the elevated entrance foyer helps in drawing high wind velocity into the interior of the building.

5. Recommendations and Conclusion

It is important to consider the effect of climate especially as it relates to solar radiation and airflow in order to make housing design thermally comfortable. Towards this end a number of recommendations lend themselves to consideration. The plot layout and general site planning housing estates should not be seen as solely planning problems which was the case with FESTAC Town and V. G. C. the site layout of both of which was designed by town planners. Architects with good and commanding understanding of the climates of the locality should be influential members of the design team so as to take care of the climate-related issues in developing the general site layout right from inception. It is a reality that though government regulations for planning approval address such issues as size of development, set-backs, density, number of units, parking requirements etc, which are just mere physical problems, regulations guiding issues of thermal comfort are either non-existent or are generally poorly articulated. For instance, the requirement for cross-ventilation merely anticipates the provision of two window openings are appropriately located, of adequate or required sizes or have the orientational capacity to allow for effective air flow to enhance thermal comfort is an issue clearly beyond the scope of the expectations of the legislation. Therefore it is important for architects to ensure that those other climatic factors affecting thermal comfort as already established in this thesis are given adequate consideration in the design of houses. They should pay attention to design of windows and fenestrations in general for climatic reasons and not just for aesthetics. Government legislation in this regard to firm up the loose requirements is desirable and advocated.

In conclusion, the need for architects to focus on this approach of design as it enhances users' well being, healthier internal environment and positive ecological effects in the human eco-system becomes primarily imperative. In fact it is an approach that enables the killing of two birds with a stone in that it has cost-saving effects on energy. This is clearly evident in the Unilag Terrace Housing, which is quite successful in this regard.

Tables:

Case Study1: 3- Bedroom Semi-Detached House at House 22, I Close 5TH Avenue Festac Town

Table 4

a. Sitting Room

Serial	Time	Td^{O}C	Tw^{O}C	RH%	GT^{O}C	Air Vel $^{m/s}$	MRT^{O}C	CET^{O}C
1.	08.00hrs	30.0	26.0	70	30.3	0.3	30.5	27.1
2.	10.00hrs	30.5	26.0	68	30.7	0.4	31.0	27.2

3.	12.00hrs	31.5	26.0	62	31.8	0.4	32.0	27.7
4.	14.00hrs	32.0	26.0	60	32.3	0.3	32.5	27.7
5.	16.00hrs	31.5	25.5	60	31.7	0.4	32.0	27.7
6.	18.00hrs	30.5	26.0	68	30.8	0.4	31.0	27.2
7.	20.00hrs	30.5	26.0	68	30.8	0.4	31.0	27.2
b. Bedroom								
1.	08.00hrs	30.5	26.0	68	30.7	0.3	31.0	27.3
2.	10.00hrs	31.0	26.0	66	31.3	0.3	31.5	27.5
3.	12.00hrs	31.5	25.5	60	31.8	0.2	32.0	27.5
4.	14.00hrs	32.0	26.0	60	32.3	0.2	32.5	27.8
5.	16.00hrs	31.5	25.5	60	31.8	0.3	32.0	27.3
6.	18.00hrs	31.0	26.0	66	31.2	0.3	31.5	27.5
7.	20.00hrs	30.5	26.0	68	30.7	0.3	31.0	27.3
d. Kitchen								
1.	08.00hrs	31.0	26.0	66	31.2	0.2	31.5	27.8
2.	10.00hrs	31.5	25.5	60	31.8	0.2	32.0	27.8
3.	12.00hrs	32.0	26	60	32.2	0.2	32.5	28.2
4.	14.00hrs	32.0	26	60	32.3	0.2	32.5	28.2
5.	16.00hrs	31.5	25.5	60	31.7	0.2	32.0	27.8
6.	18.00hrs	31.5	25.5	60	31.7	0.2	32.0	27.8
7.	20.00hrs	31.0	26.0	66	31.3	0.2	31.5	27.8
d. Outdoor								
1.	08.00hrs	29.5	26.0	74	29.8	0.5	30.0	26.8
2.	10.00hrs	30.0	26.0	70	30.0	0.5	30.5	26.7
3.	12.00hrs	30.5	25.5	64	30.7	0.6	31.0	26.9
4.	14.00hrs	31.0	25.0	60	31.3	0.6	31.5	26.9
5.	16.00hrs	30.5	25.5	64	30.8	0.5	31.0	26.9
6.	18.00hrs	30.0	26.0	70	30.2	0.5	30.5	26.9
7.	20.00hrs	30.0	26.0	70	30.2	0.5	30.5	26.9

Case Study 2: 4-Bedroom Semi-Detached House at House Q16, Road 47, Victoria Garden City, LekkiI, Lagos

Table 5

a. Sitting room

Serial	**Time**	**Td^{O}C**	**Tw^{O}C**	**RH%**	**GT^{O}C**	**Air Vel m/s**	**MRT^{O}C**	**CET^{O}C**
1.	08.00hrs	30.0	26.0	70	30.2	0.4	30.5	26.9
2.	10.00hrs	30.5	25.5	64	30.7	0.4	31.0	26.9
3.	12.00hrs	31.5	26	62	31.8	0.3	32.0	27.6
4.	14.00hrs	31.5	26	62	31.8	0.3	32.0	27.6
5.	16.00hrs	30.5	25.5	64	30.7	0.4	31.0	26.9
6.	18.00hrs	30.0	26.0	70	30.2	0.4	30.5	26.9
7.	20.00hrs	30.0	26.0	70	32.0	0.4	30.5	26.9
b. Bedroom								
1.	08.00hrs	30.0	26.0	70	30.2	0.35	30.5	27.0
2.	10.00hrs	30.5	26.0	68	30.7	0.4	31.0	27.0
3.	12.00hrs	31.5	25.5	60	31.7	0.35	32.0	27.5
4.	14.00hrs	32.0	26.0	60	32.3	0.35	32.5	27.0
5.	16.00hrs	31.0	25.5	62	31.2	0.4	31.5	27.2
6.	18.00hrs	30.5	26.0	68	30.7	0.4	31.0	27.2
7.	20.00hrs	30.0	26.0	70	30.2	0.4	30.5	27.0

c. Kitchen								
1.	08.00hrs	31.0	25.5	62	31.3	0.6	31.5	27.0
2.	10.00hrs	31.0	25.5	62	31.3	0.6	32.5	27.0
3.	12.00hrs	31.5	26	62	31.7	0.6	32.0	27.4
4.	14.00hrs	32.0	26	60	32.2	0.6	32.5	27.6
5.	16.00hrs	31.5	25.5	60	31.8	0.6	32.0	27.2
6.	18.00hrs	30.5	25.5	64	30.7	0.6	31.0	27.0
7.	20.00hrs	30.5	25.5	64	30.7	0.6	31.0	27.0
d. Outdoor								
1.	08.00hrs	29.5	26.5	78	29.7	0.6	30.0	26.9
2.	10.00hrs	30.0	26	70	30.2	0.6	30.5	26.9
3.	12.00hrs	30.5	25.5	64	30.7	0.7	31.0	26.9
4.	14.00hrs	31.0	25.0	60	31.2	0.7	31.5	26.9
5.	16.00hrs	30.5	25.5	64	30.7	0.6	31.0	26.9
6.	18.00hrs	30.0	26.0	70	30.2	0.6	30.5	26.9
7.	20.00hrs	29.5	26.0	74	29.7	0.6	30.0	26.8

Case Study 3: 4-Bedroom Terrace House at University of Lagos, Akoka, Lagos

Table 6

a. Sitting room

Serial	**Time**	**Td^{O}C**	**Tw^{O}C**	**RH%**	**GT^{O}C**	**Air Vel m/s**	**MRT^{O}C**	**CET^{O}C**
1.	08.00hrs	29.5	26.5	78	29.8	0.6	30.0	26.8
2.	10.00hrs	30.0	25.5	68	30.2	0.6	30.5	26.5
3.	12.00hrs	31.0	25.5	62	31.2	0.7	31.5	26.8
4.	14.00hrs	31.0	25.5	62	31.2	0.7	31.5	26.8
5.	16.00hrs	30.0	25.0	66	30.2	0.7	30.5	26.2
6.	18.00hrs	29.5	26.0	74	29.7	0.7	30.0	26.5
7.	20.00hrs	29.0	26.5	80	29.3	0.6	29.5	26.5
b. Bedroom								
1.	08.00hrs	29.5	26.5	78	29.8	0.6	30.0	26.8
2.	10.00hrs	30.0	25.5	68	30.2	0.6	30.5	26.5
3.	12.00hrs	31.0	25.5	62	31.2	0.7	31.5	26.8
4.	14.00hrs	31.0	25.5	62	31.2	0.7	31.5	26.8
5.	16.00hrs	30.0	25.5	66	30.2	0.7	30.5	26.2
6.	18.00hrs	29.5	26.0	74	29.7	0.7	30.0	26.5
7.	20.00hrs	29.0	26.5	80	29.3	0.6	29.5	26.5
c. Kitchen								
1.	08.00hrs	30.5	25.5	64	30.5	0.7	31.0	26.8
2.	10.00hrs	31.0	25.0	60	31.3	0.7	31.5	26.8
3.	12.00hrs	32.0	26	60	32.2	0.7	32.5	26.9
4.	14.00hrs	32.0	26	60	32.3	0.7	32.5	26.9
5.	16.00hrs	31.0	25.0	60	31.2	0.7	31.5	26.8
6.	18.00hrs	30.5	25.5	64	30.7	0.7	31.0	26.8
7.	20.00hrs	30.0	25.5	68	30.3	0.7	30.5	26.6
d. Outdoor								
1.	08.00hrs	29.5	26.5	78	29.7	0.6	30.0	26.7
2.	10.00hrs	30.5	25.5	68	31.2	0.6	31.0	26.7
3.	12.00hrs	31.0	25.5	62	31.7	0.7	31.5	26.8
4.	14.00hrs	31.5	25.5	60	31.7	0.7	32.0	26.0
5.	16.00hrs	30.5	25.0	62	30.7	0.7	31.0	26.4

6.	18.00hrs	29.5	26.0	74	29.7	0.7	30.0	26.4
7.	20.00hrs	29.0	26.5	80	29.3	0.6	29.5	26.7

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