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Evaluation of Climate Indicators for Passive Solar Design Optimization

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Abstract - The purpose of conducting this research work was for evaluating the climate indicators of Entebbe region for finding out how to optimize the outputs of passive solar design which are based on the design strategies that are very specific for Entebbe region. The method involved in this research is the use of an advanced energy designing tool software known as climate consultant which allows the user to identify every little weather detail of a place. The findings of this study suggested that the optimization of passive solar design can be achieved with the inclusion of the passive design strategies found on the psychrometric chart of the place.

Keywords - Climate indicators, passive solar design, passive design strategies, occupant comfort range, sustainability.

I. INTRODUCTION

In the pursuit of achieving sustainability in the building sector for the past few decades, it has been noticed that climate factors do have an important role in making buildings more energy efficient. This implies that the adoption of passive strategies which only rely on the natural resources which can be renewed can extremely reduce the conventional way in which buildings consume energy [1-5].

People's economic growth is usually accompanied with a certain degree of trying to improve the level of comfort in their residence which is unfortunately most of the time done by using other means that are not environmental friendly. It is true that not all types of climate can only depend on passive strategies for providing comfort to their occupants, but optimizing the use of all natural renewable resources available before adopting active strategies can reduce the building's footprint on the ecosystem [6-10].

The global ongoing challenge of climate change has made the building designers and architects extend their boundaries in the search of building that can exhibit a dynamic response for each seasonal change. The approach to be used to make this dynamic response of buildings possible is

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through the inclusion of climate indicators that are specific for each region during the initial phase design of buildings [11-15].

The climate indicators that are evaluated in this study belong to Entebbe location. Climate indicators such as dry bulb temperature, humidity level, sky cover, ground temperature and the psychrometric chart of the location will be represented in a graphical form for the purpose of visualizing every little climate detail of the location.

II. METHODOLOGY

To ensure that every little climate detail is taken into account, an advanced energy designing tool named as climate consultant software was adopted for this purpose. The software used in this study allows the user to choose the desired location in which the analysis has to be done, after the selection of the location the user has to decide the type of standard to be followed during the whole process of data analysis. In this study the ASHRAE standard 55 was opted as the guiding standard for this analysis.

III. ANALYSIS

The below table exhibits all the type of climate data involved in this analysis

Table1. Climate data involved in the analysis

Monthly means	January	February	March	April	May	June	July	August	September	October	November	December	Units
Global horizontal radiation(average hourly)	491	511	520	452	416	418	442	456	472	518	467	496	Wh /sqm
Direct	416	418	393	265	272	313	337	329	312	408	344	437	Wh

normal radiation(average hourly)													/sqm
Diffuse radiation(average hourly)	196	203	210	243	212	186	190	201	226	197	213	191	Wh/sqm
Global horizontal radiation(maximum hourly)	1032	1073	1075	1025	954	919	953	1000	1025	1065	1022	1009	Wh/sqm
Direct normal radiation(maximum hourly)	892	886	873	826	847	844	847	846	858	880	860	897	Wh/sqm
Diffuse radiation(maximum hourly)	462	512	490	484	546	442	472	456	526	481	468	470	Wh/sqm
Global horizontal radiation(average daily total)	5894	6132	6249	5427	4999	5017	5306	5476	5670	6219	5611	5952	Wh/sqm
Direct normal radiation(av	4993	5026	4724	3187	3268	3760	4053	3951	3745	4902	4134	5243	Wh/sqm

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erage daily total)													
Diffuse radiation(average daily total)	2359	2444	2530	2916	2546	2240	2291	2422	2716	2375	2557	2298	Wh/sq m
Global horizontal illumination(average hourly)	57599	60285	61372	52425	48440	48508	52139	53687	55448	61233	54654	58179	Lux
Direct normal illumination(average hourly)	25825	25579	25245	17993	17622	20993	21344	20805	19986	25900	21749	26557	Lux
Dry bulb temperature (average monthly)	22	23	23	22	22	22	22	21	22	22	22	22	Degree ^0C
Dew point temperature (average monthly)	19	18	18	19	19	19	17	18	18	18	18	18	Degree ^0C
Relative humidity(average monthly)	80	74	77	81	85	84	76	82	81	79	81	79	Per cent
Wind direction(m	180	160	250	180	180	180	190	0	0	240	240	240	Degrees

Vol. 6, Issue 2, 2020, pp 47—58
ISSN: 2395- 0196

onthly mode)													
Wind speed(average monthly)	2	2	1	2	3	3	2	2	2	2	2	2	m/s
Ground temperature (average monthly of 3 depths)	21	21	22	22	22	22	22	22	22	22	21	21	Degree ^0C

Temperature variation

As it can be clearly seen from the figure below, the temperature variation of this location does not swing away from the comfort zone which is shown on the legend section of this figure on the left.

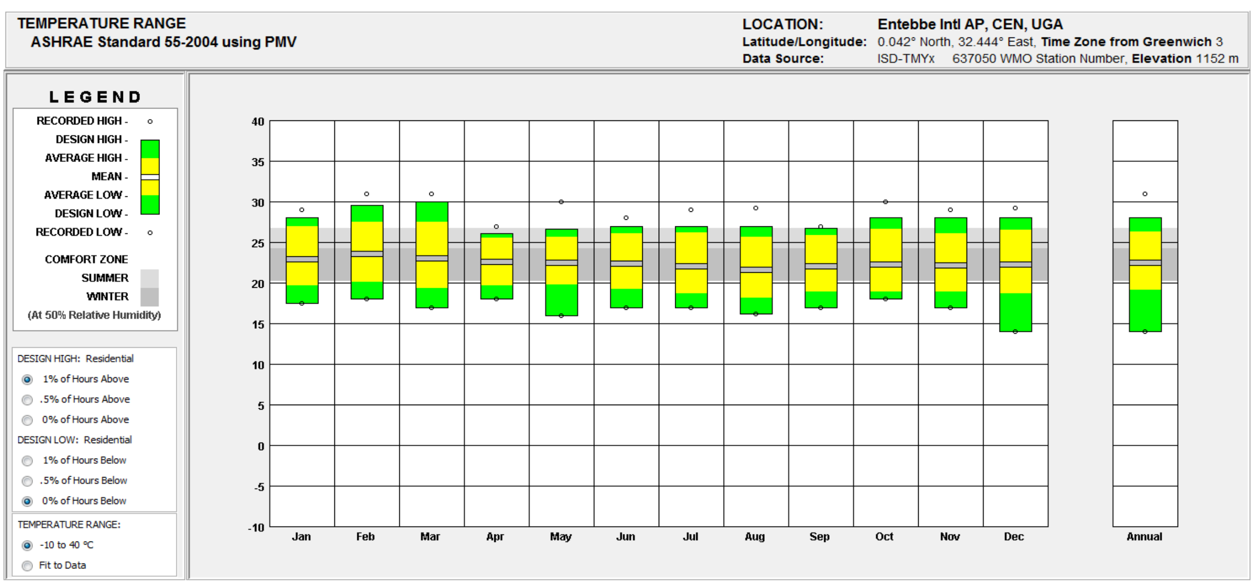

Figure1. Temperature variation

Monthly diurnal variation

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From this figure below six variables are represented together on the same graph, these variables are: dry bulb mean temperature, wet bulb mean temperature, dry bulb temperature, global horizontal radiation, direct normal radiation and diffuse radiation. Maximum radiation is observed in the month of March and October.

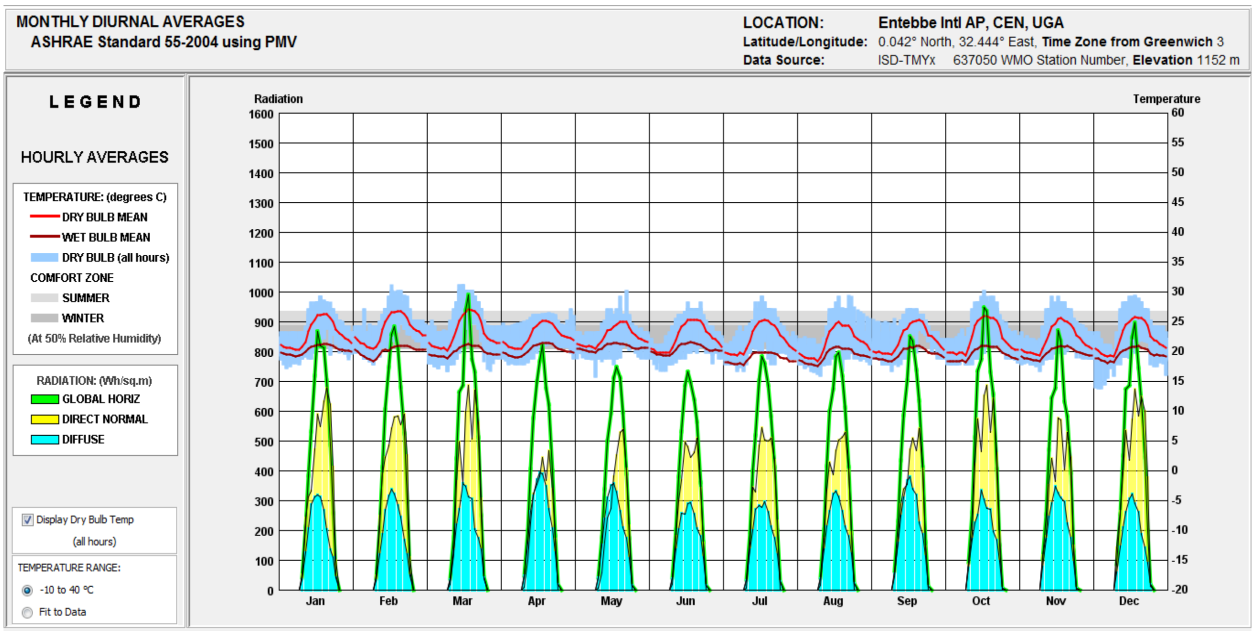

Figure2. Monthly diurnal variation

Sky cover range

The sky cover range shown in the figure below shows how much does the chosen place gets cloudy or completely clear in each month of the year.

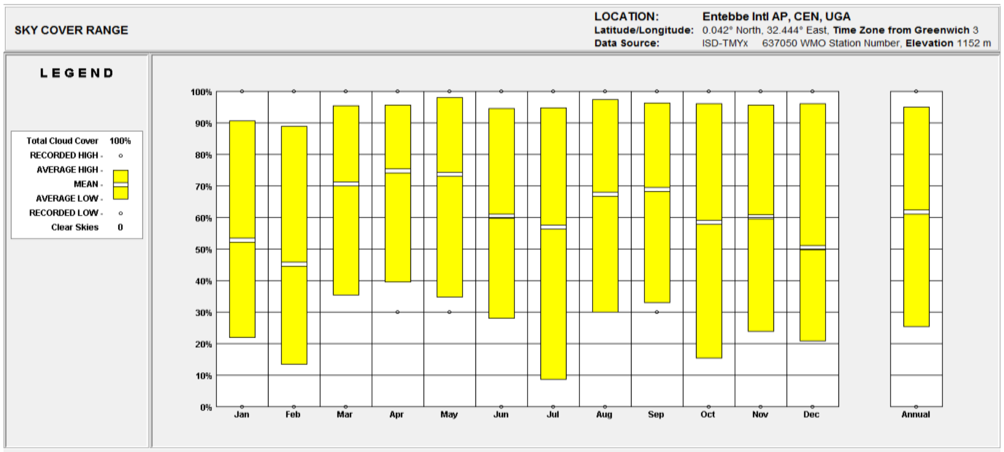

Figure3. Sky cover range

Ground temperature variation

Ground temperature is taken into account when there is a need of installing earth air tunnel or during the construction of a specific foundation required to be maintained at some specific temperatures. Figure below exhibits the ground temperature variation for 0.5 meters, 2.0 meters and 4.0 meters below the ground level.

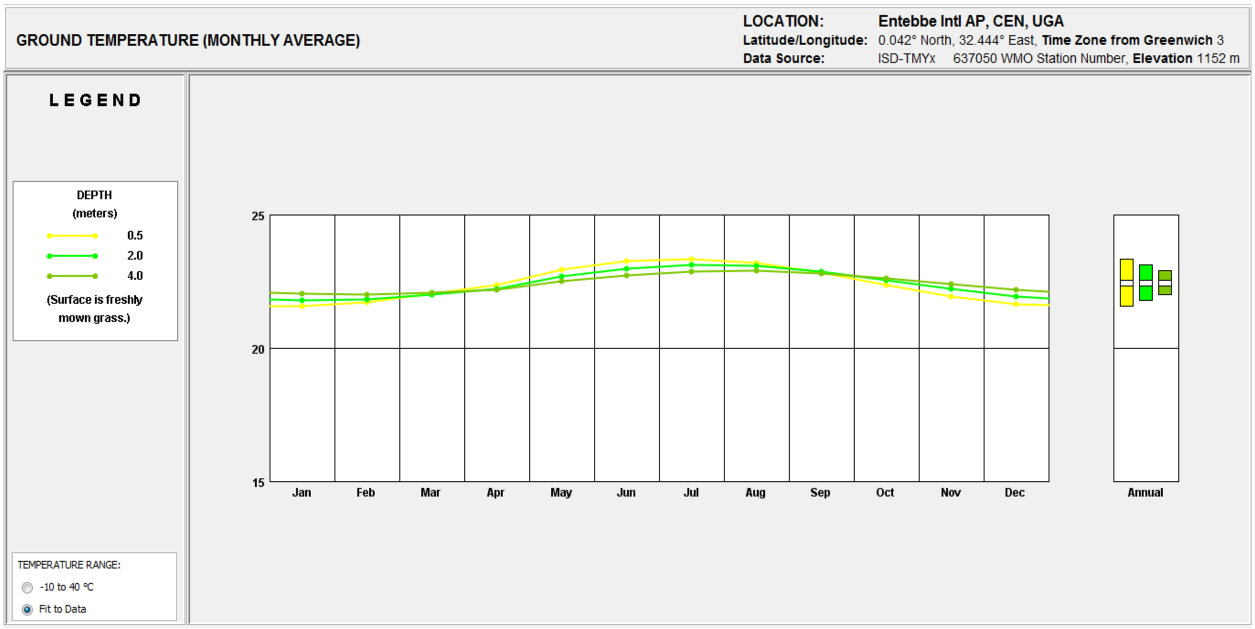

Figure4. Ground temperature variation

Temperature and relative humidity variation

Temperature and relative humidity of a place are two major factors that influence the way people judge the thermal comfort satisfaction of a place. This figure below exhibits their variation along the year.

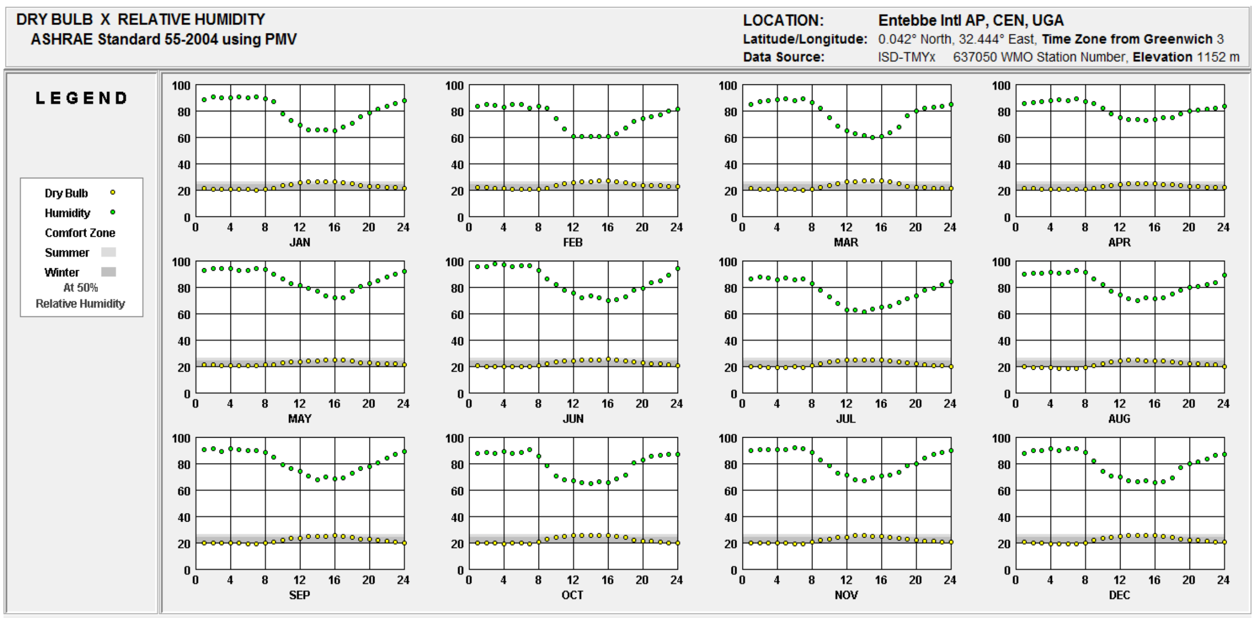

Figure5. Temperature and relative humidity variation

Sun shading chart

Knowing the exact position of the shading device which can provide full shade whenever required is one of the important steps in establishing the required shade of a place. Figure below shows the sun shading chart of this location.

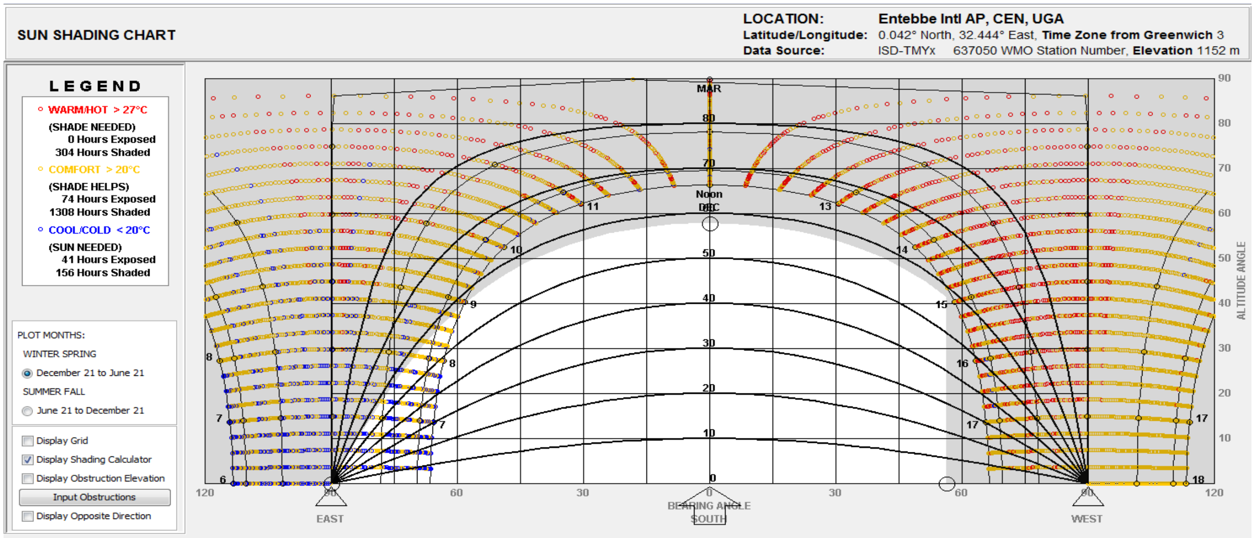

Figure6. Sun shading chart

Psychrometric chart

This is the chart from which the user can choose the right passive design strategies that can offer both environmental and economical benefits.

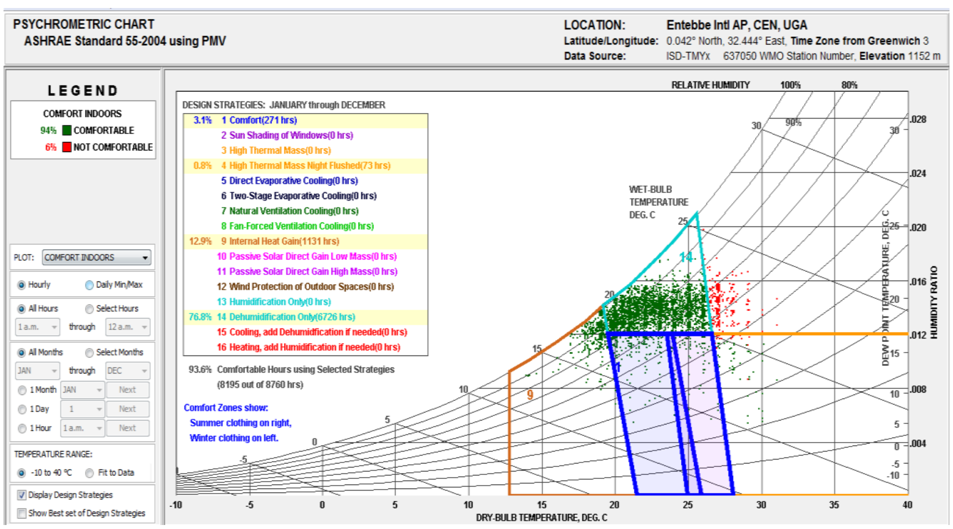

Figure7. Psychrometric chart

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IV. RESULTS AND DISCUSSIONS

Based on the analysis conducted and with the help of the design strategies suggested on the psychrometric chart, following points can be deduced.

High thermal mass night flushed

The use of high thermal mass materials inside the building requires a consistent procedure of cooling down these materials at the night time by the help of the cool outdoor air. This is done for optimizing the capability of these high thermal mass materials to absorb or store the solar heat during the daytime of the following day.

Internal heat gain

In the night time when the indoor temperature become less inferior to the ambient room temperature there is a requirement of a heating source, this heat required can be generated from the thermal mass materials available inside of the buildings. Thus the heat stored in the daytime by the thermal mass materials of the building has to be released so as to raise the temperature back to the comfort zone.

Dehumidification only

As observed on the temperature and relative humidity variation graph, the place experiences a lot of moisture in the air which makes it to be too much humid. Implementing dehumidification can be done through the use of natural ventilation means in the building. This is to say that the building must be provided with enough of air inlets opening to allow the outdoor air to flush out the humid air present inside the building.

V. CONCLUSION

Having observed the way all climate indicators vary, adopting a passive solar design approach can be achieved easily through the inclusion of passive design strategies seen on the psychrometric chart. Taking into account the high humidity observed, the incorporation of natural ventilation means is very imperative for maintaining a healthy indoor environment.

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Vol. 6, Issue 2, 2020, pp 47—58
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