ASSESSMENT OF THE NATURE AND TYPES OF HVAC BUILDING SERVICES INSTALLATIONS USED IN HOTELS IN OWERRI AND THEIR CONFORMITY TO ASHRAE STANDARD

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Abstract
The Proliferation of Hotels and the corresponding high need for excellent Heating, Ventilation and Air Condition (HVAC) systems to provide a year-round indoor comfort in buildings regardless of the type or temperature outside in Owerri are in no way parallel with any city in Imo State and South East at large. According to the Energy Conservation Building Code (ECBC), (2007) HVAC systems account for between 40-50% of the public building energy usage. In view of this, this paper sought to determine the type and nature of HVAC Building service installations used in the Hotels in Owerri, ascertain the variations between HVAC installations with the standard requirement as stipulated by ASHRAE Standard 62.1 and 62.2 in the quest to avoid energy wastage. The research was pursued by means of literature review and field survey entailing the use of a well-structured questionnaire and a checklist adapted from the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard for HVAC installation. The result revealed among others that the most common type of HVAC systems used in the hotels is Unit Packaged HVAC equipment, some of which were old and worn out and that occupants/customers are at liberty to use the HVAC system any time of the day in the Hotel. Also the result revealed that the HVAC installations were not consistent with specifications of ASHREA Standard 62.1 and 62.2. HVAC components system has not been of adequate maintenance and the installations have not been consistent with the ASHREA Standard. Therefore, the study recommends HVAC installation conformity with the Standards

Key word: Type of HVAC system, Installation to Conformity

Introduction

In spite of the environmental problems connected to energy production, people's expectations of the service standards in buildings are much higher now than in the past. In other words, growth in population, enhancement of building services and comfort levels, together with the rise in time spent inside buildings, have raised building energy consumption to

the levels of transport and industry (Pérez-Lombard *et al,* 2008). It has also been observed the increasing rate of installation of HVAC installations in building which have now become almost essential in parallel to the spread in the demand for thermal comfort, considered a luxury not long ago. Therefore, it is important to also focus on the usage of energy.

The energy used by a building is broadly determined by the building fabric, the building services and the management of the building and the occupants' day to day activities. Moreover, with growing global concern for environmental sustainability, it is imperative to promote sustainable design, enhance building's performance and reduce environmental impact (Okafor, Hassan, and Awal*,* 2008).

Among Building services, the growth in Heating Ventilation and Air Conditioning (HVAC) system energy use is particularly significant, contributing 50% of building consumption and 20% of total consumption in the USA (Perez-lombard, Ortiz, and Pout, 2008).

In non-domestic buildings, the type of use and activities make a huge impact on the quality and quantity of energy services needed. Nonresidential building include the Public Building as well as the industrial buildings which account for a large amount of the energy consumption in the building sector (Energy Information Administration, International Energy, 2006).

The growing reliance on HVAC systems in residential, Public and industrial environments has resulted in a huge increase in energy usage, particularly in the summer months. Developing energy efficient HVAC systems is essential, both to protect consumers from surging power costs and to protect the environment from the adverse impacts of greenhouse gas emissions caused by the use of energy inefficient electrical appliances.

In general, the trend of installing HVAC systems increases in public and public buildings like Hotels even in Nigeria. However, while other countries have taken the lead of sorting out their energy challenges by evaluating the energy usage and its related factors, the case in Nigeria has been focused mainly on developing sustaining energy production measures. Conversely, this paper is channeled towards evaluating the nature and type of HVAC installations in the Hotels in Owerri with particular interest on its conformity with the ASHRAE Standard and consequently its energy implication.

Methodology

The study was pursued through the use of a well-structured questionnaire and a checklist consistent with ASHRAE Standard 62.1 and 62.2. Details of the sample size, data collection instrument, design and administration of the questionnaire and data analysis instrument are as presented in this section.

Sample Size

The population being studied are public buildings with particular interest in the Hotels in Owerri Municipal. In the context of this study the public buildings allowed relatively unrestricted access and these could include educational and research facilities, car parks entertainment halls and

offices. However dues to lack of access and the need to maintain uniformity of data the study opted for only Hotel buildings in owerri municipal
Cochran's sample size calculation procedure was employed to determine the appropriate sample size in this study. To do this, Cochran's return sample size formula is first determined using the formula presented in equation 1 (Cochran, 1977)

$$N_0 = (z^2pq)/d^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where;

n = the desired sample size
z = the ordinate on the Normal curve corresponding to or the standard normal deviate, usually any of the following determined based on the 'margin error formula'

i) A 90% level of confidence has α = 0.10 and critical value of zα/2 = 1.64.
ii) A 95% level of confidence has α = 0.05 and critical value of zα/2 = 1.96.
iii) A 99% level of confidence has α = 0.01 and critical value of zα/2 = 2.58.
iv) A 99.5% level of confidence has α = 0.005 and critical value of zα/2 = 2.81.
P= the proportion in the target population estimated to have particular characteristics (normal between the range of 0.1 to 0.5
q = 1.0-p
d = degree of accuracy corresponding to the confidence level and Z selected.

For the purpose of this study, a confidence level of 95% was adopted owing to the fact that the questionnaire was geared towards evaluating perception on monitoring.

Consequently, the sample size is determined as thus,
z = 1.96, d = 0.05 where p = 0.5, q =0.5
N_o= (1.962X0.5X0.5)/ (0.05)2= 384
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Therefore a total of three hundred and eighty-four will be administered to the various respondent's staff and occupants of the Hotels inclusive).
Thus, after calculating using Cochran's formula for sample size of 384 respondents (see Equation 3.1), the number of hotels from which the various respondents will be drawn will be deduced from the formula for calculating sample sizes given a known population.

Data Collection Methods and Instruments

As earlier stated that the data set needed for this research is both quantitative and qualitative (i.e. Mixed design research). Applying the mixed

research design approach in collating the data set needed to address the research objectives. A questionnaire and a checklist was adopted

Design and Administration of Questionnaires

The questionnaire was structured to be consistent with the major aspect of the research such as the research questions and the objectives of the research. The questionnaire was administered to occupants and/staff of the hotels. The questionnaire were used to investigate issues relating the management, operations, control, maintenance and installation of the HVAC systems in the Hotels and will however, be was prepared in five point Likert scale.

Checklist

A checklist was adopted to investigate if there is variation with the HVAC system installation in the hotels from the general provision of ASHRAE Standard 61.1 and 62.2 for thermal comfort and HVAC installations. In view of this, the checklist was used to investigate the HVAC system installations conformity to the following key aspects:

i. The installed Equipment
ii. The airflow through the heat exchanger
iii. Water flow through the water exchanger
iv. System Documentation
v. Customer education

Method and Instrument of Data Analysis

The data collected for this study was subjected to various statistical analyses using the computer based software “Statistical Package of Social Sciences” (SPSS). The results of the analysis were presented in the forms of table for the purpose of easy comparison and clear expression of the findings. Also, Data obtained through questionnaires were analyzed using mean score, standard deviation, Relative Importance Index and t-test to test the research hypotheses. All analysis was done using Statistical Package for Social Science (SPSS) version 19. Further, the analyses were presented in tables and chart.

The Mean Score were computed using this formula:
Mean-score = $\mathbf{(X_1W_1+X_2W_2+X_3W_3+ \ldots\ldots\ldots\ldots X_nW_n)/N}$ .....(2)
Where
W = Weight of answer choice
X = Response count for answer choice
N = Total Numbers of the Respondents

From the computation, most significant constraint factor in a subset was one with the highest Mean-Score value. The factor having an average

or higher value is considered significant as shown in Equation 1, while the insignificant factors are identified using Equation 2.

Significant constraint factor: MR > 2.5 ………………………. (1)

Non-significant constraint factor: MR < 2.5 ……………………….. (2)

Where:

1 < M< 5 on 5-point Likert rating scale

Based on the mean score (M) values of the constraints in a given set, the variable were ranked or rated.

The standard deviation was computed using this formula:

$$\sqrt{EFi(xi - X)/EFi} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

Where:

X = Mean

Efi= Means the frequency of the ith item

Relative importance indices (RII) were also used to rank Areas of Emphasis during Project Monitoring. The Relative Importance Index (RII) was calculated for each document according to their frequency of use as suggested for use by Memon et al, (2006) and Othman et al, (2005)

RII ranges between zeros to one. The five-point Likert scale ranking was transformed to relative Importance Indices (RII) for each of the construction contract documents. The weighted average for each item was determined and ranks were assigned to each item, representing the perception of the respondents

Relative Importance Index (RII)

$$= \frac{\sum fx}{\sum f} \times \frac{1}{k} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

Where,

∑fx = is the total weight given to each attributes by the respondents.

∑f = is the total number or respondents in the sample.

K = is the highest weight on the likert scale.

Results are classified into three categories as follows (Othman et al, 2005) when;

RII<0.60 -it indicates low frequency in use

0.60≤RII<0.80 -it indicates high frequency in use.

RII≥0.80 –it indicates very high frequency in use

Finally, the data analysis were presented table's and chart's form. However, the analyses were aided using the SPSS (i.e. Statistical Package for the Social Sciences) software.

RESULT AND DISCUSSION

Building Operating Characteristics

Table 1: Building Operating Characteristics

S/N	Variable	Option	Frequency (No)	Percentage (%)
1	hotel operate throughout the whole year	a) Yes	314	91.8
		b) No	28	8.2
		c) Don't Know	-	-

		Total	**342**	**100**
2	Occupant have the privilege to operate the HVAC at all times through the day	a) Yes	324	94.7
		b) No	18	5.3
		c) Don't Know	-	-
		Total	**342**	**100**
3	how many hours is an occupant privileged to operate the HVAC in a Day	a) 0-3hrs	6	1.8
		b) 4-6hrs	24	7.0
		c) All through the night 9.pm-6.am	312	91.2
		Total	342	**100**
4	operational logs including repair, maintenance summary available	a) Yes	98	28.7
		b) No	232	67.8
		c) Don't Know	12	3.5
		Total	**342**	**100**
5	Are HVAC manual available	a) Yes	113	33.1
		b) No	151	44.1
		c) Don't Know	78	22.8
		Total	**342**	**100**
6	Are all the rooms occupied every day of the week	a) Yes	288	84.2
		b) No	54	15.8
		c) Don't Know	-	-
		Total	**342**	**100**
7	Are the electricity bill for the building available	a) Yes	305	89.2
		b) No	37	10.8
		c) Don't Know	-	-
		Total	**342**	**100**
8	specific staff assigned to management of energy or plant operation	a) Yes	76	22.2
		b) No	266	77.8
		c) Don't Know	-	-
		Total	**342**	**100**
9	type of HVAC system is in use in the building	a) Centralized system	10	2.9
		b) Room Conditioning Unit Packaged HVAC equipment	332	97.1
		Total	**342**	**100**
10	Type of room packaged HVAC equipment	a) Radiators/ Convectors	-	-
		b) Roof Top Units	55	16.1
		c) Self-Contained Air Conditioners and thro wall heat pumps	189	55.3
		d) Remotely cooled contained Air Conditioners and heat pumps	98	28.6
		e) Heat Pump Loop	-	-

		System		
		f) Direct Fired Heating Units	-	-
		Total	**342**	**100**

Source: Field Survey, (2018)

The operation characteristics of the building with regards to the HVAC system was assessed and the analysis of the respondents' opinion is as presented in Table 1. From the Table, most of the hotels (91.8%) operate throughout the year. Also, with regards occupants/customers privilege to use the HVAC at all-time of the day, 94.7% of the respondents attested that occupants/customers are at liberty to use the HVAC system any time of the day in the Hotel. Also, enquiry on the number of hours an occupants must be provided with electricity to use the HVAC system in the hotel was conducted and the result shows that, 91.2% of the respondents attested that such privileges are more certain throughout the night.

With regards to the tendency of having the rooms maximally occupied in the hotel, 84.2% of the respondents attested to the act that most of the hotels are maximally occupied every day of the week. The researcher sought to know if there are HVAC manuals provide at the hotel rooms to guide occupants/customer in using the system, the result revealed that a larger number of the hotels (44.1%) do not available such manual; 33.1% claim to provides while 22.8% of the respondent claim not to be aware of such provision.

Also, the respondent were asked the type of HVAC systems in use in the Hotels and to that, 97.1% attested to the fact that the HVAC were majorly Room Conditioning Unit Package HVAC equipment. Further enquires on the type of packaged HVAC equipment in use in the hotels revealed that the most common type use is the self-contained air conditioners and thro wall heat pumps (55.3%). This was closely followed by the remotely cooled contained air conditioner and heat pumps (28.6%) and Roof top Units (16.1%)

Finally from Table 1, it can be deduced that there are rarely any specific staff assigned in the hotels to manage the energy or plant operation as attested by 77.8% of the respondents. Other details are as presented in the Table

Energy Management in the Hotels

Table 2:Energy Management of the Hotels

S/N	Variable	Option	Frequency (No)	Percentage (%)
1	Who is responsible for energy management	a) Building operators	198	57.9
		b) Maintenance Contractors	132	38.6
		c) Nobody	12	3.5
		Total	**342**	**100**
2	Is there an Energy consumption budget	a) Yes	68	19.9
		b) No	218	63.7
		c) Don't Know	56	16.4
		Total	**342**	**100**
3	Fraction of energy budget constituted by	a) Less than ¼	-	**-**

	HVAC system consumption	b) ¼ to ½	10	2.9
		c) ½ to ¾	12	3.5
		d) Over ¾	46	13.5
		e) Don't Know	274	80.1
		Total	**342**	**100**
4	Does the building management review or carry out analysis of energy consumption	a) Yes	232	67.8
		b) No	65	19.0
		c) Don't Know	45	13.2
		Total	**342**	**100**
5	what time intervals are the energy consumption review carried	a) 0 to 6months	-	-
		b) 7 to 12months	31	9.1
		c) 13 to 1months	109	31.9
		d) Over 18 months	135	39.5
		e) Never done	67	19.5
		Total	**342**	**100**
6	familiar with the operation procedure of the HVAC system installed	a) Yes	278	81.3
		b) No	64	18.7
		Total	**342**	**100**
7	come across any placard explaining operation or any other issue concerning the HVAC system in this Hotel	a) Yes	44	12.9
		b) No	298	87.1
		Total	**342**	**100**
8	How is the maintenance of this building organized	a) Whenever there is faulty operation	166	48.5
		b) On regular basis	30	8.8
		c) Whenever funds allow	146	42.7
		Total	**342**	**100**
9	waiting period taken to repair reported faults in the building	a) Less than 3days	2	0.5
		b) 3days to one week	18	5.3
		c) 1 week to 2 weeks	16	4.7
		d) 2 weeks to 3 weeks	82	24.0
		e) 4 weeks	78	22.8
		f) Over 4 weeks	146	42.7
		Total	**342**	**100**

Source: Field Survey, (2018)

The HVAC energy management processes in the hotel was assessed carried and the result of the respondents are as presented in Table 2. From the result, it is seen that 57.9% of the respondent attested that building operators are responsible for the energy management; 38.6% claim it's the maintenance contractor while only 3.5% of the respondent claim not to know who is responsible for the energy management of the hotel.

The result also reveal that most of the hotels do not have energy consumption budget as attested by 63.7% of the respondents; though 19.9% of the responds claim hotel they work have energy budget while 16.4% of the respondents affirmed to the fact that they truly do not know if there exist any of such budget. With regards to the fraction of the energy budget allotted to HVAC energy consumption, 80.1% of the respondent attested that they do not know the Fraction of energy budget constituted by HVAC system to the energy consumption of the building. However, 13.5% of the respondent who claim to know attested that HVAC energy consumption is allotted three-quarter the entire energy budget of the hotel.

Also from the Table 67.8% of the respondents attested that the building management do carry out a review of the energy consumption. However, with regards to the frequency of the review: 39.5% of the respondents' claim it takes over 18months to review the energy consumption; 31.9% claims it takes between 13-18months, 9.1% claim it's between 7-12months, whereas 19.5% claim that the review is never done.
The results also show what informs the maintenance of the HVAC system and from the result it can be seen that 4.5% of the respondent attested to the fact that HVAC systems in the hotel is only maintained when there is a faulty operation of the system. 42.7% claim maintenance are only carried out whenever funds allow while only 8.8 % claim it is carried out on a regular basis

Finally regarding the energy management of HVAC systems, the 42.7% claim the waiting period taken to repair HVAC system when reported takes over four (4) weeks. 22.8% claims it take four (4) weeks; 24.0% claim it take 2-3weeks while 4.7% claim it take a week or two.

Conclusion

The most common type of HVAC system used in almost all the Hotels is the Unit Packaged HVAC equipment and as such the number of HVAC units in the Hotels were almost exactly the number of rooms in the Hotels excluding those in the receptions and offices. Also with the number of floors in the hotels being within to 0-3floors above ground floor and with an average number of rooms of within the range of 31-40 rooms it show cases the average number of HVAC units in each Hotel. The average age of use of the HVAC systems in most of the hotels to be between 7-9years from date of installations. Also wing to the fact that occupants/customers are neither restricted in any way to the use of the HVAC systems, nor is there any provided guide, misused is often the report and consequently energy wastage. To this, the need for HVAC control system and the most common HVAC operation control type and strategy used in most of the Hotels studied is 'On/off toolbox'

There is an unsatisfactory and unacceptable general observation of the HVAC system (this entails; valve tagging, pressure gauge installations and automatic air vent installations) contrary to the provision/requirement of ASHRAE Standard 62.1 and 62.2. There are also reoccurring bad temperature sensors connection to (Direct Digital Control) DDC and faulty Selector switch connection to DDC in most of the hotel HVAC control system.

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