ARCHICULTURE

A Journal that promotes the Architecture of Human Culture with the Culture of Architecture

Vol. 3. (1), December, 2020

ISSN: 2636-6747

A publication of the Department of Architecture, University of Jos

ARCHICULTURE
VOL 3 No. 1 DECEMBER 2020
ISSN 2636-6747

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Contact us:
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Printed by:
Designed+Prints @ Great Prouider Printing and Publishing House:
No. 35 Tafawa-Balewa Street, Near Baptist Church, Jos
07031266863, 08029123007
email: godwinagaba33@gmail.com

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Architectural Interventions for Passive Cooling of Hotel Buildings in Minna, Nigeria

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Abstract

Globally, hospitality ranks as being high in energy demand and high energy consumption. Energy is used to provide comfort and services in hotel buildings, accounting for20-50% of the energy use. In Nigeria, the price of energy and its expenses has rapidly increased which underscores the need for energy conservation for sustainable buildings, the input of the built environment professionals. The aim of this research was to find from the opinion of the Built environment professionals on passive techniques as it relates to energy conservation on the design of hotel buildings in Minna. The methodology used in carrying out this research was by administration of questionnaire to the built environment professionals in Minna. The questionnaires were analysed with the aid of the SPSS software package and measured using, Pearson product moment correlation and the Likert scale and presented with the use of tables and charts with the aid of Micro-soft Excel. Findings indicate the need for more awareness on energy conscious integration of passive designs in hotel design to reduce dependence on energy use which could be electrical or mechanical for lighting and thermal comfort. The paper concludes that passive techniques in building designs could lead to hotel buildings that are energy efficient, sustainable and environmentally friendly.

Keywords: energy conservation, energy use, hotel buildings, integration, passive designs.

1.0 Introduction

The increase in energy costs and environmental disasters has caused a global resolve for a more sustainableand long-term preservation and better quality of life in the-twenty first century and beyond(Mohamed, 2017). The hotels being a part of the hospitality industry play are important as guests, visitors, and tourists are offered accommodation and its allied facilities in exchange of payment(Chan & Mackenzie, 2013). Therefore, it is imperative for owners and managers of hotels to be aware of the impact of energy conservation, their running costs and carbon emissions on the environment (Chong & Ricaurte, 2014:Hotel Energy Solutions, 2011). Low energy efficiency practice has consequently made hotels to take up a bulk of the energy and resources in the hospitality industry (Bohdanowicz*et al.*, 2001). Researches carried out on buildings in Greece, China, UK, Malta and UAE suggest that energy efficiency is attainable when approached with appropriate measures (Gonzalez &Yousif, 2015; Wang *et al.*, 2015;Krestiniti, 2017; Jonesa*et al.*, 2017;Ibrahim, 2017). In recent times, several efforts are being directed to achieving sustainabilityacross all sectors in the society. As a result of these efforts, different groups have generated their own rating systems equivalentto theirsocietal and natural environments requirements. In addition, to achieving sustainability, other groups have set up authorization points that require every construction to adhere to, in elevating the effectiveness of public part in design process (Ibrahim, 2017).

It is therefore necessary that the opinion of the built environment professionals in every society on the pressing issues of using passive techniques and energy use in building is known so that researches can be made in such a way that they are tailored to be related to and applicable by the profesionals. The factors that can influence the use of passive techniques for energy conservation and energy efficiency in Hotel buildings in Minna as studied in this paper includes;

- Acceptance of passive design techniques for lighting and cooling (which includes ventilation)
- Suggested possible minimum time of use of active qualities for lighting and cooling
- Importance of passive techniques in some selected parts of a hotel for lighting and cooling
- Most suitable passive techniques for hotel buildings in Minna metropolis
- Challenges of integrating passive techniques in hotel buildings in Minna

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2.1 Hotel Buildings and Energy Consumption

Hilton Team (2015)noted that energy is logically the second or third major cost for a regular hotel, as it is imperative for the use of power appliances, heating, cooling, lighting and air conditioning. The International Energy Agency(IEA) (2013)also noted that buildings have a share of about 80% of Total Final Consumption (TFC) globally as an energy source. The revenue of a full-service hotel has between 4% and 6% going to its operating costs. There is apossibility of saving 20%-50% by reducing energy use from the lighting system, heating, ventilating and air conditioning systems (E Source Customer Direct Brochure, 2004; International Cablemakers Federation(ICF-International), 2008). It was found that heating, catering, domestic hot water and lighting are the main energy consumers in a hotel building (CADDET, 1997). Hence, the key elements to be engaged in order to be able to lower the energy usage in a hotelbuilding are the HVAC (Heating, Ventilation and Air Conditioning), lighting system and laundry. (San Diego Gas & Electric Company (SDGE), 2010).

The comfort of the guests and staff in a hotel can be ensured along with the reduction of operating costs when energy conservation measures are properly applied (E Source Customer Direct Brochure, 2004). According to Wang*et al.*(2015) the feasibility and possibility of reducing energy consumption is surebecause there exists a variety of factors that have been recommended. The reason for it is that they lead to high level of energy use in a hotel building and they include the climate of the location of the hotel, the hotel features, the technical equipment and the building materials used (Upadhyay*et al.*,*2017*). The actions of the occupants inhabiting in low energy buildings contribute largely to their actual energy consumption (Jones*et al.*, 2017). Low energy design of urban environment and buildings in heavily populated regionsneedcontemplation of a broad array of factors including urban setting, transport planning, energy system design, and architectural and engineering details (Omer, 2003). Kapiki (2010) pointed out that in Thessaloniki in Greece,certifications and energy-saving practices for; electricity and water consumption reduction are important in addition to the fact that deliberate energy saving measures on hotels can show the way to the reduction of their operating costs.

2.2 Passive Design Techniques for Low Energy Use

The challenge for architects and other building professionals today is to design and promote low energy buildings in a cost effective and environmentally responsive way. The study and improvement of the quantity of the built environment and living conditions should be encouraged by the built environment professionals (Omer, 2003). Integrating passive techniques in building design requires a good understanding and analysis of thermal comfort, energy performance and the local climate of the building(Mikler, Bleed, & Breines, 2009).Selecting the appropriate technology and equipment and reducing air-conditioning and lighting energy use is the key to energy savings in the hotel (Gu, Zhao, & Ma, 2012).In Greeceit was found in a research by Krestiniti (2017), through simulation that building envelope measures can causenoteworthy reductions that involves both heating and cooling needs, therefore implying thatintegrating passive techniquesis good for energy conservation and usefuleconomically.

The hotel proprietors and hotel designers haveimportantoptions to think about, the carrying out of strategic measures on energy use is an investment that is both interesting and not too cost demanding and has very low impacts on the environment (Parpairi, 2017). Integrating passive techniques in the design of buildings have been discovered to be schemes that could be efficientin causing adecreasein energy consumption with diversefactors like climatic zone, building typology anddetermining the design technique that could satisfactorilyfit it(Bodach, Lang, & Auer, 2016). According to theKS Architects(2009) architectural group, there are three primary factors that are to be critically considered in determination of energy conservation or efficiency of a space:

1. *Air- ventilation*
2. *Light – artificial lighting control*
3. *Heat- Cooling and heating*

The Integrated Energy Design process centres on using passive qualities in realizing maximum comfort and as minimum active qualities as possible in terms of installations, adjustments and other technical systems involving ventilation, cooling and lighting(KS Architects, Denmark, 2009).

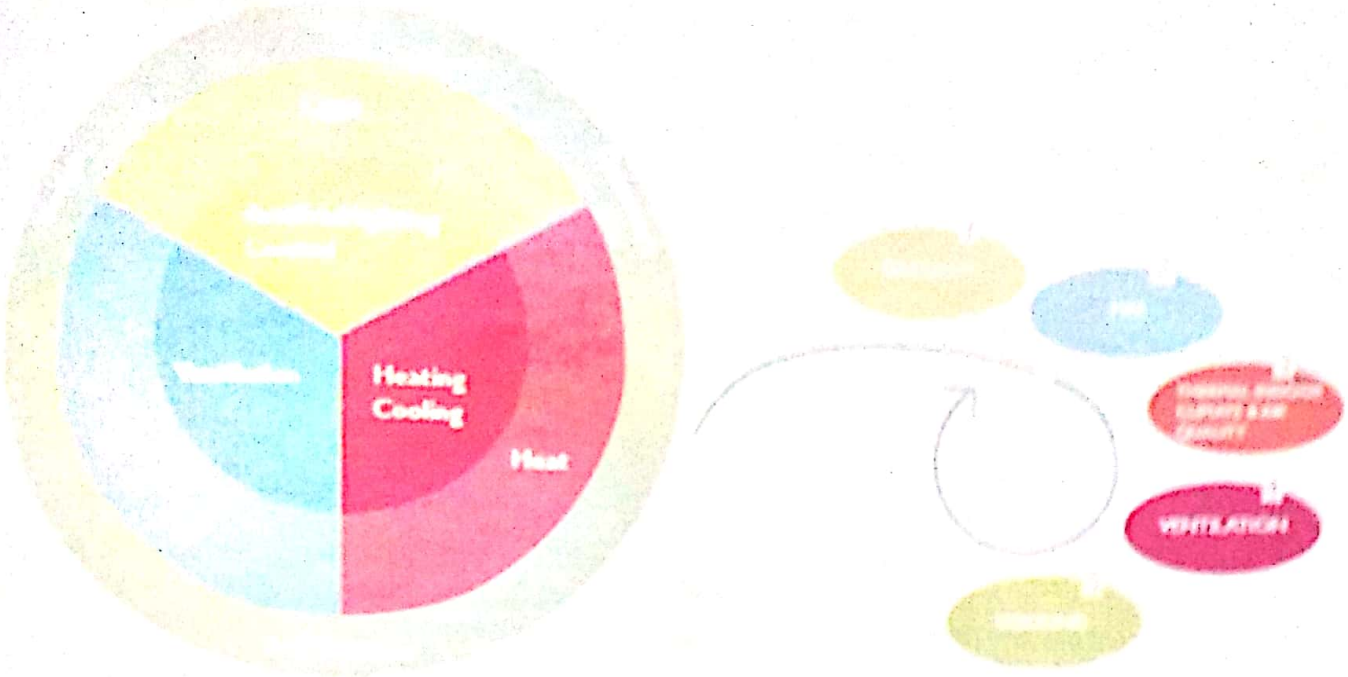

Figure 1.0: Integrated Energy Design Process
Source: KS Architects, 2009

These factors also play a role on the general wellbeing of the occupants of the hotel building and this is often evident through the equipment, fixtures and fittings like the lighting bulbs, revolving fans and air conditioners that are installed in the hotels all towards maximum comfort.Akande*et al.*,(2015) noted that the design and construction stages are basic and important in the provision of energy efficient buildings that are comfortable and effective at their designated purpose. To that effect, in making a better indoor environment quality, the following are involved; daylight, ventilation, and cooling(https://www.whittlesea.vic.gov.au).

Laustsen(2008)suggests that achieving energy efficient built environment with less expense starts as early as the design phase from the costs of some efficiency improvements like; construction costs, energy improvements, works on the building envelope and HVAC systems. Some constructions that might need efficiency improvements include concrete floors and hidden pipes or foundations.The increase in the energy efficiency of an entire building can be started by considering both the architectural and energy designs together. As the mechanical systems, electrical systems, and structural systems would be affected in the incorporation of passive solar technologies and the implementation with the guidance of information from building simulation software (Littlefield *et al.*, 2009).

Therefore, the process of achieving energy conservation in a building would best work as integrating passive techniques with the variables in the building design stage(Lewis, 2004).The essence of seeking the view of the Built Environment Professionals (BEPs) in terms of passive techniques for energy efficiency and conservation was deduced from the conclusion of the works of Omer (2003), Gu*et al.*(2012) and Parpairi (2017) which suggested that it is possible for the building professionals to achieve low energy buildings even from the design stage. As they contribute in the conception, design, planning and registration of the building before its construction. From the literatures that were reviewed, it was deduced that the use of passive techniques for energy conservation and energy efficiency in Hotel buildings are viable. These can also be applied in a wide range of ways along with the minimum use of active qualities for lighting and cooling

3.0 Research Method

The aim of this research was to pin point from the opinion of the built environment professionals their perception of passive techniques on energy conservation and efficiency on the design of hotel buildings in Minna. The findings were weighed to observe the flow and trend of the opinions of the BEPs. The BEPsconsidered include architects, builders, quantity surveyors and civil/structural

engineers, others considered includes planners, estate valuers, mechanical and electrical engineers. The data for this work was collected through the use of questionnaires which were administered to one hundred (100) BEPs in Minna.

Table 1.0: Number of Professionals perresponse

	Profession				
		Sample size	Response Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Architects	30	27	32.5	32.5	32.5
	Quantity surveyors	15	14	16.9	16.9	49.4
	Civil engineers	10	5	6.0	6.0	55.4
	Builders	20	16	19.3	19.3	74.7
	Others	25	21	25.3	25.3	100.0
	Total	100	83	100.0	100.0	

The sampling technique used for this survey wasstratified random samplingmethod, with the Architects as the designers of the building taking the most of the strata with 30% as is on Table 2.0 and from The Architects Registration Council of Nigeria (ARCON)(2013), the number of accredited architects located in Minna was about 23. Hence 30 questionnaires were allocated for the strata of architects as the prime consultant(The Nigerian Institute of Architects, 2000) with room for an increase as at the time survey was taken while the questionnaires for the other professionals were allocated by quota with 20 going to builders, 15 to quantity surveyors and 10 to civil/structural engineers, while 25 were administered to planners, estate valuers, mechanical and electrical engineers (Table 1.0).

The questionnaire is made up of two sections as, the first section is made up of closed ended questions about energy conservation and its relevance in the design of hotel buildings and the second section is comprised of open ended questions inquiring of their opinion on the passive techniques that can help in energy conservation and the possible challenges that could affect their application in hotel buildings in Minna.Eighty three (83) questionnaires were answered as at the moment they were picked up, with 89.16% of the closed ended part of the questionnaire answered and 83.13% of all the retrieved questionnaires had theopen ended questions responded to.Out of the 83 questionnaires collected were 32.5% from architects, 16.9% from quantity surveyors, 19.3% from builders and building technologists, 6% from civil engineers and 25.3% from the other professionals (which includesplanners, estate valuers and mechanical and electrical engineers). The data retrieved were analysed with the aid of the SPSS package. The results from the questionnaires were measured using, Pearson product moment correlation and the Likert scale and presented on tables and charts.

4.0 Results and Discussion

The outcome proves opinions on passive techniques from the view of the Built Environment Professionals on the usefulness and application in hotel building designs in conserving energy. There is a wide range of opinions on the perceptions and use of passive techniques that were suggested for the energy conservation in the hotel buildings in Minna. The results from the questionnaires that were administered is discussed with the use of doughnut charts, stacked column in 3D, Pearson product moment correlation, Likert scale and bubble diagram.It can be seen from Figure 2.0 that a high percentage of the BEPs view that passive techniques can be used for energy conservation in the hotel buildings in Minna. It is in agreement with KS architects (2009) as it is on Figure 1.0, that even in the maximum utilization of passive techniques for day-lighting and passive cooling, there would be times in which active alternatives may be used to supplement, and to this effect these active means might be required for a specific period of time per day.

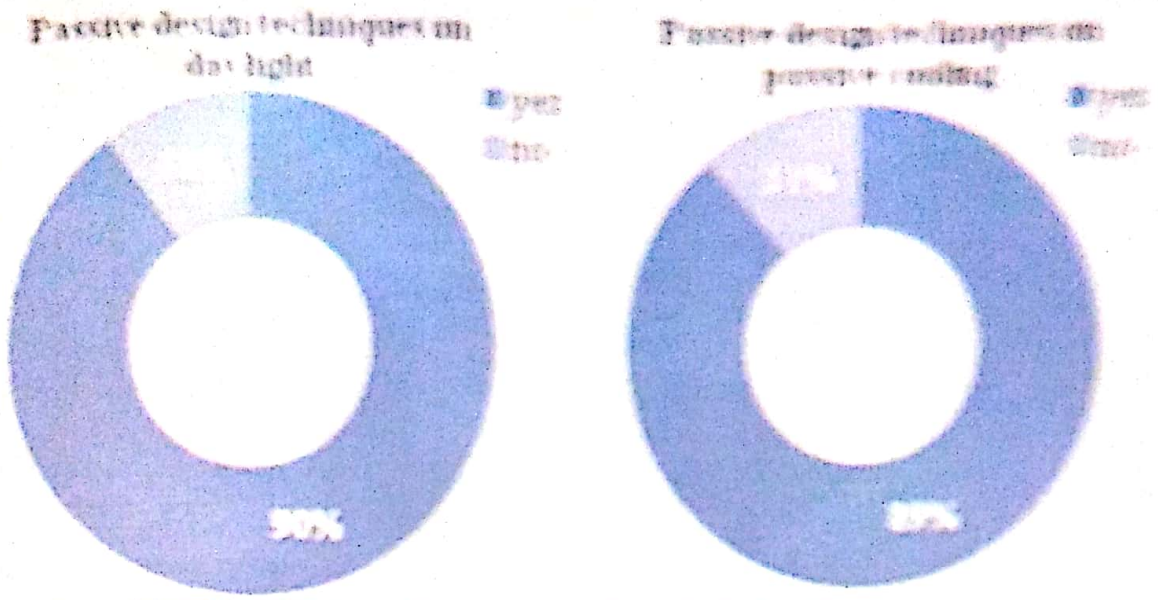

Figure 2.0 Effectiveness of energy conservation in the design of hotels
Source: Author's fieldwork, 2017

It was observed from Figure 3.0 that a majority of the professionals in the built environment agree that the minimum time that these active techniques like the artificial lighting and HVAC systems can be used to supplement day-lighting and passive cooling respectively is from 7 to 12 hours per day.

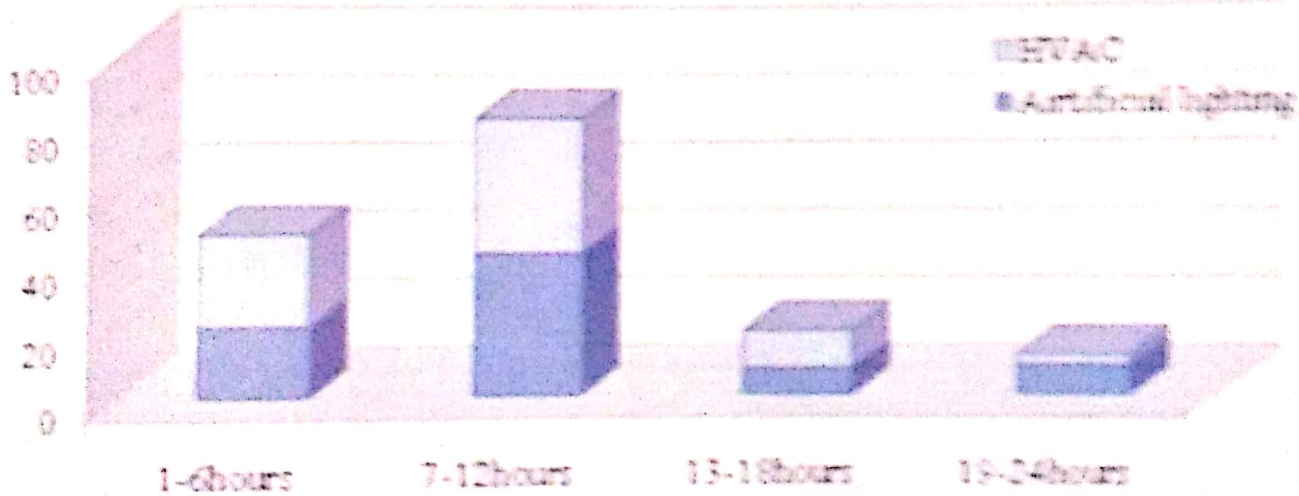

Figure3.0 Maximum allowable time of use of active systems for energy conservation in hotel buildings
Source: Author's fieldwork, 2017

Values of 1-4 were assigned to the optionsfor the questions on the importance of some passive techniques. The significant relationship of their response for both energy use systems were analyzed with two (2)-tailed test and a level of significance at 0.05for this correlation analysis. The results from the test of the statistics that was carried out with the Pearson product moment correlation for the significant relationship between the suggested maximum time of use for the artificial lighting and the HVAC systems in hotel buildings. From the data used for Figure 3.0, the test showed that there is a significant relationship between the preferred times of maximum use of the artificial lighting and HVAC systems in ensuring energy conservation as calculated in Table 2.0.

Table 2.0: Correlations of Suggested time of use for both artificial lights and HVAC Systems

		Artificial lights	HVAC
Artificial lights	Pearson Correlation	1	.282
	Sig. (2-tailed)		.012
	Sum of Squares and Cross-products	48.765	15.380
	Covariance	.610	.197
	N	81	79
HVAC	Pearson Correlation	.282*	1*
	Sig. (2-tailed)	.012	
	Sum of Squares and Cross-products	15.380	64.688
	Covariance	.197	.819
	N	79	80

*. Correlation is significant at the 0.05 level (2-tailed).

A one-sided scoring of 1-4 was allocated to the diverse alternatives for the respondents due to their insight of the variable being considered. The scoring of the alternatives includes: Very Unimportant (1), Unimportant (2), Important (3) and Very Important (4). Tables 3.0 and 4.0explains that the majority of the respondents are extends within the very important section of the scale of measurement. The number of respondents in each section is multiplied by the weighted score allocated to it; the calculation for this is shown in Tables 3.1 and 4.1, the total score across the rows are added up and offered as the total at the end of the Table.

Table 3.0: Number of respondents per opinion on importance of day-lighting for energy conservation in parts of a hotel building

Measured variable	Very unimportant X1	Unimportant X2	Important X3	Very important X4	Total
Corridors	5	8	26	35	74
Bedrooms	5	4	33	32	74
Conference halls	4	2	25	43	74
Reception area	7	2	26	37	72
Stairs area	4	7	26	37	74
Restaurant	3	6	37	27	73

Table 3.1: Sum of the responses on importance of day-lighting for energy conservation in parts of a hotel building

Measured variable	Very unimportant X1	Unimportant X2	Important X3	Very important X4	Total
Corridors	5	16	78	140	239
Bedrooms	5	8	99	128	240
Conference halls	4	4	75	172	255
Reception area	7	4	78	148	237
Stairs area	4	14	78	148	244
Restaurant	3	8	111	108	230

Table 4.0: Number of respondents per opinion on importance of passive cooling (natural ventilation inclusive) for energy conservation in parts of a hotel building

Measured variable	Very unimportant X1	Unimportant X2	Important X3	Very important X4	Total
Corridors	4	9	39	20	72
Bedrooms	4	2	32	36	74
Conference halls	2	3	32	38	75
Reception area	3	4	35	32	74
Stairs area	5	18	33	17	73
Restaurant	4	4	31	34	73

Table 4.1: Sum of the responses on importance of passive cooling (natural ventilation inclusive) for energy conservation in parts of a hotel building

Measured variable	Very unimportant X1	Unimportant X2	Important X3	Very important X4	Total
Corridors	4	18	117	80	219
Bedrooms	4	4	96	144	248
Conference halls	2	6	96	152	256
Reception area	3	8	105	128	244
Stairs area	5	36	99	68	208
Restaurant	4	8	93	136	241

It can be observed from tables 5.0 ad 6.0 that majority of the respondents are of the opinion that both day-lighting and passive cooling are important for the spaces in the hotel, this is imperative of the fact that all the spaces in a hotel design should be considered for proper day-lighting and passive cooling in order to achieve energy conservation and energy efficiency.

Table 5.0: importance of day-lighting for energy conservation in parts of a hotel building

Measured Variable		Sum	Mean	Interpretation
Rating of Corridors	74	239	3.23	Important
Rating of Bedrooms	74	240	3.24	Important
Rating of Conference halls	74	255	3.45	Important
Rating of Reception area	72	237	3.29	Important
Rating of Stairs area	74	244	3.30	Important
Rating of Restaurant	73	230	3.15	Important

Table 6.0: importance of passive cooling (natural ventilation inclusive) for energy conservation in parts of a hotel building

Measured Variable		Sum	Mean	Interpretation
Rating of Corridors	72	219	3.04	Important
Rating of Bedrooms	74	248	3.35	Important
Rating of Conference halls	75	256	3.41	Important
Rating of Reception area	74	244	3.30	Important
Rating of Stairs area	73	208	2.85	Important
Rating of Restaurant	73	241	3.30	Important

Most of the professionals believed that both passive cooling and day-lighting are important (about 46% and 42% respectively) and very important (about 40% and 51% respectively) in the selected areas (corridors, stair areas, bedrooms, conference halls, reception area and restaurants) for energy conservation to be achieved in the hotels in Minna city.The results obtained from the open ended questions in the questionnaire showed the popularity of the respective passive techniques known to the BEPs through the sizes of the bubbles and the respective purpose of their application with their location of the different axes on the chart on Figure. 6.0. On Figure 6.0; A- Use of openings, B- Use of courtyards and atriums, C- Building orientation, D-Proper landscaping, E- Use of shading devices, F-Evaporative cooling, G- wind catchers and wind towers, H-Use of air tunnel, open corridors, green roofing,solar shading and use of traditional building materials, I- Use of skylights, J-composite construction, K- Use of light tubes, L- Use of curtain walls.

The most popular passive technique was found to be the "A"- use of the openings (this includes the consideration of their sizes, location, quality, types and quantity) to aid in enhancing day-lighting in the hotel buildings while for passive cooling, it was "D"- proper landscaping. Techniques like "I", "J", "K" and "L" were only suggested for day-lighting and similarly "D", "E", "F", "G" and "H" were only suggested for passive cooling.

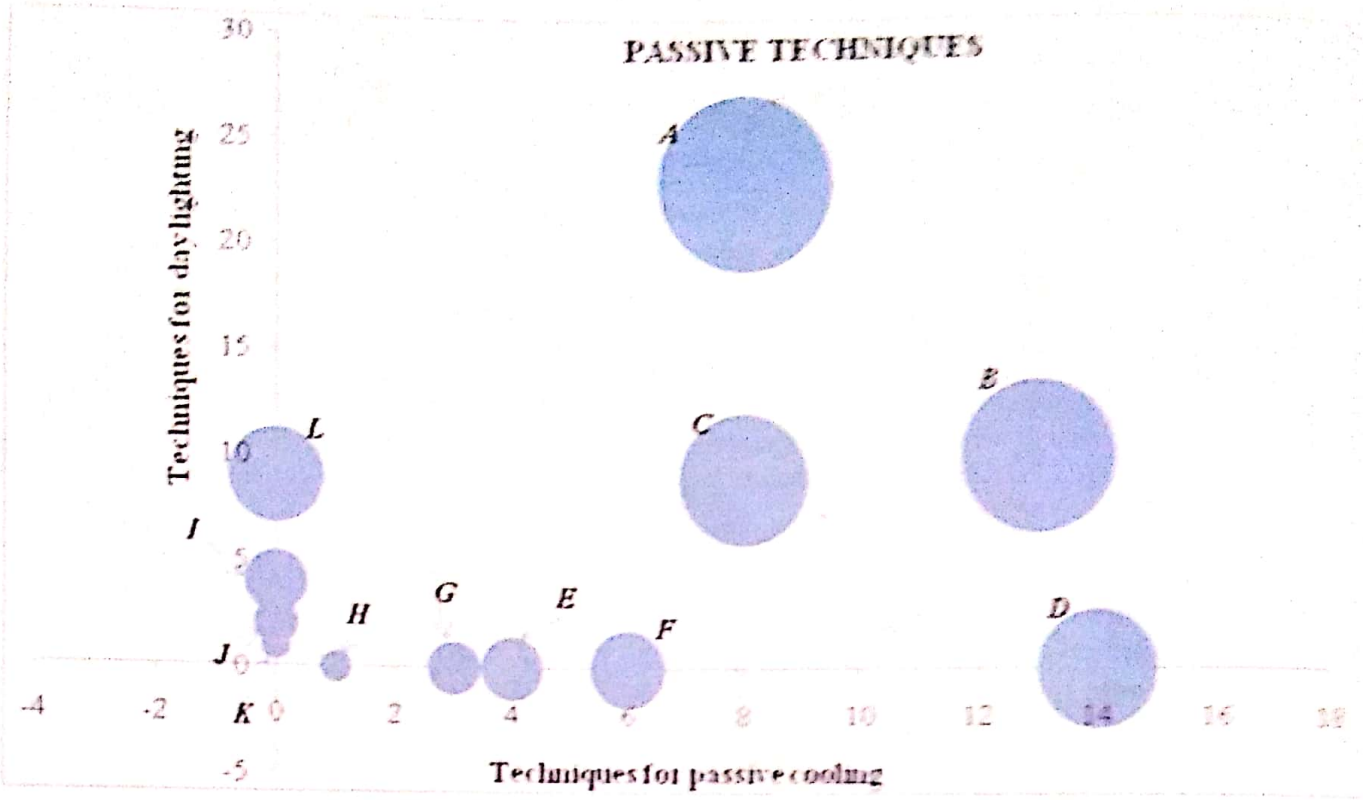

Figure6.0: Suggestions of passive techniques for hotel buildings in Minna to cause energy conservation
Source: Author's fieldwork, 2017

The challenges that the Built Environment Professionals face that could also affect the use of passive techniques for energy conservation in Minna as shared by the BEPs are outlined on Table 7.0. They are outlined in descending order based on popularity; the most common challenges shared by the professionals (BEPs) are the feared cost of maintenance in the application of passive techniques on buildings, the presence of little or no awareness of passive techniques on buildings and the uncertainty about the possibility of energy conservation in a building.

Table 7.0: Challenges for passive techniques for hotel buildings in Minna

S/N	**Challenges according to the BEPs**
1	Feared cost of maintenance and application
2	Little or no awareness
3	Unavailability of materials
4	Client requirements
5	Government development control agencies
6	Insufficient skilled force for building construction
7	Indiscriminate construction of buildings
8	Little or no proper site analysis
9	Ignorance on the part of the professionals

5.0 Conclusion

The opinion of a majority of the Built Environment Professionals (BEPs) was that the application of passive techniques for more daylight and passive cooling could be effective in achieving energy conservation in hotel buildings. Tothat effect, the minimum time that a majority of them opined that the need for active qualities like artificial lighting and Heating Ventilation and Air conditioning (HVAC) systems could be required.Accordingto 52% and 48% of the BEPs, it would be for about 7-12hours in a day, for energy efficiency in the use of the HVAC and artificial lighting systems respectively. There was also an agreement from a majority of them that proper day-lighting and well introduced passive cooling techniques in the areas in a hotel building is important for energy conservation.

It was found that there was a significant relationship between the opinions of BEPs for the minimum time of use for both the HVAC and artificial lighting systems for cooling and ventilation and lighting respectively. The test for the level of importance of Energy conservation in some selected areas of the hotel building (they include; the corridors, stair area, conference halls, restaurant, bedrooms and the reception area)showed that energy conservation is important to all those areas in the hotel building. As such, both day-lighting and passive cooling if passive techniques should be applied in every space in the hotel building. Some suggested passive design techniques that could be used for energy conservation in Minna includes; strategic use of openings, courtyards and atriums, optimum use of Building orientation, Proper landscaping and the use of shading devices.

In conclusion, the BEPs in Minna have an idea of the need for energy conservation in the built environment as well as their needed contributions towards it. But, the challenges that could come with the incorporation of passive design techniques are what could be affecting their interest in them.Further research on the design of buildings would help also in achieving better hotel buildings that are not only energy efficient but also, sustainable and environmentally friendly.

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