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ABSTRACT

The concept of Building Management Systems (BMS) cannot be over-emphasized. BMSs have developed over time and are benefiting the people who utilize these kinds of facilities. The purpose of this study is to evaluate Nigeria's BMS implementation challenges. The population consists of active participants in BMS projects which include architects, mechanical and electrical engineers, quantity surveyors and builders. The sample size was found to be 90, using Kreijcie Morgan table. Simple random sampling technique was employed in the study. The study adopted survey design and used online survey to elicit information form respondents. 44 of the 90 surveys were returned and used in the research. The results demonstrated that the two biggest obstacles to BMS implementation are power supply failure and system implementation costs. The paper compared the medians of the samples from the four stakeholders who took part in the survey using the Kruskal-Wallis test at a 5% confidence level. The findings indicated that, no statistically significant difference among the respondents on BMS implementation except two factors. The two factors are the system's deployment costs and the lack of affordable intelligent building technology. Each stakeholder has a unique and varied perspective on BMS-related information, which may be the cause of the discrepancy in the outcomes. It was suggested, among other things, that power be stabilized and that other options be made available to guarantee the system's continuing operation. Lastly, BMS personnel should receive training so they can efficiently optimize each benefit the BMS provides.

KEYWORDS: Building management system, construction, procurement, maintenance

Stakeholders' Perception of Significant Challenges to the Implementation of Building Management System in Nigeria

1. INTRODUCTION

The implementation of innovative technology in building development has advanced significantly in the construction industry. A new idea known as "intelligent buildings," or "smart buildings," was developed in the construction industry as a result of the adoption of these technologies. To optimize return on investment, these buildings blend systems and innovation with deft management (Clements, 2004). It was reinterpreted as any structure that can adapt to the needs of its users, society, or organization. Given this, the following crucial components—intelligent energy, intelligent safety, intelligent buildings, intelligent water, intelligent transportation, intelligent healthcare, etc.—define a smart building or a smart city as a whole. This can optimize available resources to balance commercial, social and environmental needs. These services need to be managed in some way to make sure that their operations meet the requirements (DVI, 2017).

To do this, a building management system, or BMS, is built. Its goal is to automate and take control of every facility's functioning in the most effective and efficient manner possible, within the limitations of the installed device within a building. The Building Management System (BMS) is the primary system used to manage and control intelligent building systems. One of the essential intelligent building systems is the building management system, sometimes referred to as the buildings automation system (BAS) (Wang & Xie, 2002). An integrated system is formed by connecting multiple subsystems together to produce a building management system. BMS began in the late 1960s, coinciding with the development of the modern computer in the 1940s.Owing to their capacity to enhance building management efficiency, building management systems appear to be the best option for efficient management of all kinds of buildings (Wang, 2010). A facility that wants to guarantee a comfortable, safe, secure, and energy-efficient environment can integrate the BMS into its operations.

The energy efficiency industry in Europe is experiencing technological advancements, and the usage of artificial intelligence (AI) and the Internet of things (IoT) in energy efficiency software is growing, particularly in the residential sector. Given the rise in the number of homes with energy management systems, there is widespread prospects for BMS. Reducing emissions,

increasing the use of renewable energy, developing, and modernizing buildings to make them more energy-efficient are all urgent priorities. The system's implementation has advanced as a result of all of these.

Integrated systems are improving the tenant experience and altering building management in Asia. Modern technology, like the Internet of Things (IoT), is being utilized throughout much of Asia to monitor and improve building and installation experiences. Furthermore, Asia is not at the same level as North America and Europe, where building performance and construction are subject to stringent regulations set by certain standards (Omorogiuwa & Folorunsho, 2019).

Unfortunately, the majority of public and private buildings in developing nations confront numerous issues that add up to hurdles for the building management system's implementation, which causes the nation to adopt high technology slowly. According to Hassanain et al. (2017), "inadequate or insufficient knowledge of how this system works and the benefit derived from the installation of a BMS in one's facility" is one of the main implementation problems. Building clients take into account the "enormous" expense associated with BMS setup. The unavailability and insufficient supply of necessary materials is another ongoing obstacle to the adoption of a BMS in the construction sector (Omorogiuwa & Folorunsho, 2019).

In order to reap the benefits of building management systems (BMS), which include enhancing building performance, cutting energy and water consumption, boosting occupant comfort and safety to a certain extent, and solving operational issues faster and more effectively, it is necessary to thoroughly research the obstacles to BMS implementation as it grows in scope (Daniel et al., 2017). It is imperative that Nigeria's building sector incorporate intelligent building technologies into its multipurpose and commercial structures. Thus, this study aims to evaluate stakeholders' perspectives regarding the obstacles to BMS implementation in Nigeria's construction sector.

2. LITERATURE REVIEW

2.1 Building Management System

Building Management Systems is made up of multiple subsystems that are coupled in multiple ways to form an integrated system. BMSs are among the most significant intelligent building systems. There are numerous definitions of building management systems, some of which are included below:

Andrew (2018) defined BMSs as “intelligent microprocessor based controller networks installed to monitor and control a buildings technical systems and services such as air conditioning, ventilation, lighting and hydraulics”. More precisely, they connect the various building

equipment components so that they function as a single, cohesive system. BMS, often known as "smart building technology," includes the previously mentioned services that are crucial for overseeing industrial activities. The administration of a building's mechanical and electrical systems, as well as industrial infrastructures constitutes an improved BMS or centralized building management systems (BMS, 2021).

Ambika (2017) defined a “Building Management System (BMS) or a more recent terminology, Building Automation System (BAS) as a computer-based control system installed in buildings that controls and monitors the building’s mechanical and electrical equipment such as ventilation, lighting power systems and security systems”. According to i-Scoop (2018), a building management system (BMS) is a control system that includes hardware, software, and clearly visible communication protocols to monitor and manage a wide range of building systems and controls.

Building management systems, sometimes known as automation systems or BAS, are used in buildings to automatically monitor and regulate many services, including heating, air conditioning, lighting, plumbing, and fire protection (Mustafa et al., 2002). A sensor-controller-activator system is referred to by this name. Every single one of these can communicate with other controls and apply control algorithms through the usage of an electronic digital processor. Any hardware, controllers, connecting networks, and central controllers are all included in the term BMS. The building automation or management system, according to Allen and Remke (2008), is used to regulate a variety of operations, such as HVAC (heating, ventilation, and air conditioning), temperature, heating system, and equipment scheduling.An umbrella term known as "building automation systems" (BAS) is sometimes used to refer to "building management systems," or BMS. Wang (2010) described it as a broad spectrum of computerized building control systems, ranging from big systems with central computer stations and printers to standalone remote stations, special-purpose controllers, and standalone remote stations. The BMS systems of today are built on open communications protocols and include Web access, which enables global access and system integration from many system suppliers.

2.2 The Development and Rise of Building Management Systems

The BMS began in the 1940s, when basic functions were managed by a central control and monitoring panel during a phase known as the pre-BMS stage. The enhanced BMS, which has a high number of inputs and outputs attached to it, has more connected switches and sensors than the central control and monitoring units. The first computerized building automation control system was introduced in the 1960s, indicating another phase of BMS development. This BMS generation was the first. The evolution of the contemporary computer was the cause of it. Initially, building automation protocols were either closed-source or proprietary. Similar to an exclusive language, a proprietary protocol must be followed in order for the systems and devices that make up a BMS to speak and comprehend one another. Remote multiplexers, control panels,

and computers were connected by coaxial cable or two-wire digital transmissions, enabling easy communication between all messages, sensors, and equipment. During that period, the system also performed the following additional tasks: scheduled programming of controllable devices, reporting, high and low alarm limits, and automatic analog output resets. The limited nature of proprietary protocols compelled building owners to select just one protocol, which restricted their options for building automation technology. As a result, there was a severe lack of integration between distinct subsystems that use separate protocols. All protocols have benefits of their own, and following them correctly is a good method to maximize building systems and satisfy building owners' specific requirements while staying within their budget (BTL, 2018).Its high cost and complicated usage were the primary limitations of this generation.

The term "BMS with data gathering panel based on microcomputer" was used to describe the second generation of BMSs. This was done to address a weakness in the BMS from the first generation. The BMS was created and integrated with energy management software packages. Demand management, day/night control, duty cycle, optimal start/stop, and other features are included in the software packages. The use of minicomputers' central processing units for BMSs increased quickly as a result of its advance technology. The introduction of data collection devices, which assisted in reducing the amount of cables needed to send data between sites, was another enhancement that BTL (2018) said was present in this generation compared to the previous. This was mostly brought on by the drop in hardware prices in the 1970s. The computer and program interfaces became user-friendly at this point, eliminating the need for specialized users.

Following these, the BMS was enhanced to become a local area network (LAN) based microprocessor system. The primary driver for the introduction of new technologies in BMS was the steady decrease in the cost of microprocessors and chips. Local Area Network, which is depicted in the standard BMS system architecture, was first used by these control stations (BTL, 2018). Many standards were created and promoted as technology advanced and numerous studies were conducted to give solutions to the incompatible BMS challenges. Among the technologies that the BMS industry adopted were open protocols, standard technologies, communication, and software technologies that are commonly used by the Internet, Intranet, or inside the computing network region. Particularly when it comes to infrastructure issues, wireless communication techniques lessen the drawbacks of conventional hardwired circuits.

According to Michael (2020), the yearly growth rate of BMSs usage is between 15% and 34%. He added that it is anticipated that the building management system market was valued approximately $104 billion by 2022. A growing number of applications are implementing

building management systems. While the first BMS systems were mainly utilized for cost reduction and were used for heating and cooling, a wide variety of smart devices are now being used to boost employee productivity, save operating expenses, and secure organizations. Hospitals, data centers, airports, and hotels are all monitored and secured by BMS systems.The engineering, supply, installation, programming, and commissioning of the BMS are all included in the whole system that is delivered and purchased. They are provided by specialized integrators who are authorized resellers or have a direct relationship with the manufacturer. It is necessary for all integrators to collaborate closely with Mechanical and Electrical services as well as other contractors, and they should receive complete factory technical assistance.

2.3 Challenges to Adoption and Implementation of Building Management System

The BMS's adoption and implementation in Nigeria are fraught with difficulties, notwithstanding how lovely this feature may appear. Some of them are enumerated by other researchers and presented below.

Table 1: Challenges to the Adoption of BMS

Challenges	**Authors**
Lack of awareness	Omorogiuwa & Folorunsho (2019)
Poor or bad economy	Michael (2020)
Lack of technical know-how	Hassanain *et.al* (2017), Omorogiuwa & Folorunsho (2019)
Inadequate electricity	Ben & Margaret (2014), Daniel *et al*. (2021), Omorogiuwa & Folorunsho (2019)
Inadequate maintenance and upgrade	(BS3811:1984)
Lack of adequate training	Horwitz and Bennett (2009), Piper (2004)
Limited value (Having a lower value than expected)	Walter (2021)
Lack of ability to produce range of capabilities	Omorogiuwa & Folorunsho (2019)
Security problem	Hayden (2019), (Michael, 2020).
Lack of access to data for implementing and sustaining the process	Hassanain *et.al* (2017)
Lack of useful visualization techniques or tools that consolidate operational data that is suitable for human interpretation	Hassanain *et.al* (2017)
Inadequate coordination of different tasks among the professionals	Hassanain *et.al* (2017)
High cost of implementation of BMS	

However, a variety of difficulties that may arise over the course of building projects have an impact on how satisfied people are with these systems' performance. As a result, it's critical to recognize and look into these significant issues that affect the BMS's successful implementation. One of the main motivations behind conducting this research is that Nigeria essentially lacks a well-defined infrastructure for installing this technology. The study aims to accomplish the following goals: to ascertain the degree of adoption and factors influencing the choice of building management system in Nigeria; to explore and assess the obstacles that affect the BMS's successful implementation; and to create an action and plan adequately to address those obstacles.

3. Methodology

This study primarily used the questionnaire approach in a quantitative research design. Professionals engaged in construction operations, including architects, quantity surveyors, builders, and service engineers, make up the study's population. The sample size was established using the Krejcie Morgan equations following the acquisition of the population from the Federation of Construction Industry (FOCI) and the relevant professional institutes of the respondents. Professionals in the building sector, especially those involved in BMS projects in Lagos State, Nigeria, constitute the study population. 86 experts were found appropriate for the study. This is because there are not many professionals in Nigeria who are specialized in this type of projects. Simple random sampling was employed to select the specialists used in the study. For data collection purposes, questionnaires were used to elicit information from the experts used in the study. The significance of this data collection method lies in its ability to gather firsthand information directly from the personnel directly involved in the implementation of a building management system. The questionnaire comprises of two sections. Section A was designed to elicit information on demographic details of the experts. Section B elicited information on the challenges of adoption and implementation of BMS. The paper adopted a 5-point Likert scale in the questionnaire. Respondents were asked to rate their level of agreement on the identified challenges. Five evaluation scales were used in the study. These are; "Strongly disagree"(1), "Disagree"(2), "Not sure"(3), "Agree"(4), "Strongly agree"(5). The questionnaire was administered to experts using online survey. Respondents were assured of the confidentiality of their responses and the preservation of their names, and the goal of the study was described to them in order to obtain their agreement. Microsoft Excel and Statistical Packages for Social Science (SPSS) were used to statistically analyze the gathered data. The data was presented using descriptive and inferential statistics (Kruskal-Wallis Test). Kruskal-Wallis test is a non-

parametric substitute for one-way analysis of variance (ANOVA). Field (2013) claimed that Kruskal-Wallis test is based on ranking data.

4. RESULTS

4.1 Demographic details of the respondents

The demographic information indicated that the respondents were distributed according to their occupation. Twenty (20) architects (33.33%), fourteen (14) services engineers (23.33%), fourteen (14) builders (23.33%), and ten (10) quantity surveyors (16.67%) took part in the survey. This indicates that professionals are adequately represented in the study. The educational qualifications of the experts used in the study indicated that 4 HND holders (6.67%), 22 B.Sc holders (36.67%) and 34 M.Sc holders (56.66%) took part in the study. For professional qualifications, 56 experts (93.33%) are corporate members of their respective professional bodies. The distribution of respondents according to years of professional experience is as follows: 30% (18) of respondents have 1–5 years of experience, 40% (24) have 6–10 years, 16.67% (10) have 11–15 years, 10% (6) have 16–20 years, and 3.33% (2) have more than 20 years. The responders' extensive experience in the building business is evident.

4.2 Analysis of Research Objectives

Table 2 shows that power supply failure in Nigeria (group mean = 4.40) is the greatest challenge to the implementation of BMS in Nigeria, with cost of implementation of the process taking second position (group mean = 4.28). Lack of adequate maintenance and upgrade (group mean = 4.20) is the third most challenging factor to BMS implementation in Nigeria. Other factors are as presented in Table 2.

Table 2: Ranking responds challenges to implementation of BMS in Nigeria

SN	Challenges to Implementation of BMS in Nigeria	Architects	Services Engineers	Builders	Quantity Surveyors	Total			RL
		N=22	N=14	N=14	N=10	N=60			
		Mean	Mean	Mean	Mean	GM	Chi-Square Value	Kruskal-Wallis Asymp. Sig. p	
1.	Inadequate electricity	4.40	4.45	4.38	4.36	4.40	1.372	.632	1st
2.	High cost of implementation of BMS	4.28	4.39	4.26	4.20	4.28	14.559	.0034**	2nd
3.	Inadequate maintenance and upgrade	4.19	4.26	4.16	4.18	4.20	4.762	.514	3rd
4	Lack of access to data for implementing and sustaining the process	4.12	4.16	4.17	4.09	4.14	7.281	.241	4th
5	Lack of useful visualization techniques or tools that consolidate operational data that is suitable for human interpretation	3.88	3.89	3.76	3.90	3.86	4.926	.497	5th
6	Inadequate co-ordination of different tasks among the professionals.	3.79	3.86	3.76	3.89	3.82	3.276	.647	6th
7.	Security problem	3.78	3.72	3.74	3.77	3.75	2.875	.719	7th
8.	Perception of developers on BMS as a luxury.	3.72	3.78	3.75	3.76	3.75	7.162	.245	8th
9.	Lack of awareness	3.68	3.65	3.67	3.78	3.69	6.718	.295	9th
10.	Low cost intelligent building technology is not available	3.67	3.62	3.70	3.73	3.68	12.092	.0041**	10th
11.	No accurate documentation of how the system works making it a risky investment	3.60	3.65	3.73	3.65	3.66	2.612	.758	11th
12.	Lack of competent BMS professionals	3.62	3.65	3.71	3.59	3.64	3.429	.627	12th
13.	Nigeria is still a struggling developing country	3.65	3.55	3.62	3.54	3.59	2.532	.779	13th
14.	It is complex and hard to implement	3.09	3.19	3.22	3.21	3.18	5.174	.476	14th

Source: Field survey (2023)

Table 3 Measures to be taken to facilitate the implementation of BMS

Measures	Mean	Rank
Reduction of bottleneck in the importation of equipment associated with BMS	4.27	1st
Appropriate legislation to regulate building management system operation	4.25	2nd
An improvement in the nation's security situation	4.20	3rd
Extensive enlightenment on the benefits of building management system	4.18	4th
Regular and adequate power supply	4.14	5th
Standard maintenance manuals and work schedules should be available for performing BMS system upgrades and maintenance.	4.11	6th
Financial rewards for automated building developers	3.98	7th
Lowering the price of materials and equipment for building management systems	3.86	8th
Waivers of taxes for building automation systems	3.64	9th
Increased, suitable, and regular training for BMS staff	3.50	10th

Source: Field survey 2023

Table 3 shows that ease of procuring BMS materials and equipment ranks first. Creating enabling laws to guide and regulate the process of building automation was ranked second by the respondents. Other factors as ranked by the respondents indicated that the factors are important to improve BMS implementation in Nigeria.

4. DISCUSSION

This study examined the challenges to the implementation of Building Management System in Nigeria. The findings of this study will be discussed under the objectives of the study as stated below:

4.1 To investigate and evaluate the challenges to the successful implementation of the BMS

When a building decides to install a BMS, there are a number of obstacles that will need to be overcome. These obstacles can arise during the procurement process, during installation, or during the maintenance phase. This study, which is consistent with previous studies, reveals that power supply breakdown in Nigeria comes in first place. Because there is a lack of electricity, greater populations use solar panels or generators to make up for the shortfall. Due to the intermittent power supply, the installation of this system is exceedingly costly since the BMS cannot function properly without a continuous power source (Omorogiuwa & Folorunsho, 2019).Other difficulties include the expense of implementation, the lack of BMS specialists who are qualified to manage it and the scarcity of those who do, which naturally drives up the price when you hire them. These findings are in agreement with those of Hassanain et al. (2017), Daniel et al. (2021), Ben & Margaret (2014), Piper (2004), Horwitz and Bennett (2009), Walter (2021), Hayden (2019), Michael (2020), and other researchers. Despite the fact that these studies

span many nations and regions, the difficulties are nonetheless present, albeit to differing degrees. To evaluate the medians of the samples of all four groups of stakeholders who took part in the survey—architects, services engineers, builders, and quantity surveyors—the Kruskal-Wallis test was performed at a 5% confidence level. With the exception of two parameters, the results indicated that respondents' assessments of the difficulties in implementing building management systems in Nigeria did not differ statistically significantly. The two factors are the system's implementation cost and the lack of accessible intelligent building technologies. According to Table 2, each of these covariates have p-values below 0.05. The disparity in the results may be explained by the fact that different stakeholders hold varying and varied opinions about BMS-related information. Because these professionals have distinct backgrounds and personal interests to safeguard, their perspectives are also different.

4.2 To develop a plan of action sufficient enough to solve the identified challenges.

Having achieved the first objective of this study, it is important to create specific action plans in the form of policies that will help the Building Management System be implemented successfully. The results of this study indicate that since the BMS system is the most important item on the list, it should be simple to import. According to other studies, enacting specific legislation to direct and control the building automation process came in second. It makes installation easier when laws are in place to direct and control the system's operation (Walter, 2021). It is necessary to raise public awareness using all accessible channels in order to attract people's attention and encourage them to purchase the BMS. The variables as ranked by the respondents showed that they are all important to make implementation of building management easier.

5. CONCLUSION

The study found a number of issues that hinder Nigeria's building management system deployment. In reference to the difficulties encountered in implementing BMS, each of the issues stated had a high rating, indicating that considerable effort must be made to minimize these difficulties. All of the steps that need be made to make it easier for BMS to be adopted and implemented received high to very high rankings, although they still need to be improved. To sum up, all of these are intended to successfully sustain the system for the duration of its anticipated life and to ensure appropriate and consistent upgrades as needed, as well as to avoid the system from ending prematurely before it is implemented. The respondents' assessments of the challenges related to building management system installation in Nigeria are not statistically different, with the exception of two issues. The two factors are the system's deployment cost and the lack of affordable intelligent building technologies. The disparity in the results may be explained by the fact that different stakeholders hold varying and varied opinions about BMS-

related information. Because these professionals have distinct backgrounds and personal interests to safeguard, their perspectives are also different.

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