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Assessment of Automated Building Services (ABS) Categories and Features Prevalence in Selected Federal Capital Territory and Lagos State Buildings

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Abstract

The study assessed the various automated building services (ABS) categories and features prevalence in selected Federal Capital Territory and Lagos State buildings. This was done with a view to provide information on the effective band of ABS in selected buildings in the study area. The study utilized mixed method of data collection. The quantitative approach involves administering survey questionnaire to 50% of four hundred and fifteen (415) targeted population from 34 Control Engineers' (CE) group and 381 Facility Managers' (FM) group using simple random sampling from 18 identified ABS firms in the study area. The qualitative approach involves conducting field observation in 10 buildings with ABS features purposively selected for the study. Findings revealed high prevalence of ABS among FM group in area of security, safety and access control (100%) and electrical/lighting control (100%), while waste management control recorded the lowest prevalence (35.3%; M=1.906). Mean Score Index (MSI) analysis for FM respondents (n=191) placed ABS features in the Effective Range (Grand Mean = 3.861; α = .975), with top-ranked items being technical support, security/access control, fault detection and comfort/convenience systems. CE group (n=17) also placed ABS features in the Very Effective Range (Grand Mean = 3.610; SD =1.29), led by security, alarm monitoring, and safety control. Field observation further confirmed key prevalence categories in door access, security, lighting, HVAC, cooker and electronics control. The study concluded that ABS exhibits measurable effectiveness differentials, with security, lighting, HVAC and safety features consistently highest-rated.

Keywords: Categories, Features, Prevalence, Automated Building Services, Buildings, Nigeria

Introduction

Building services installation (BSI) is a significant components of buildings that are crucial for the performance, functionality, efficiency, comfort, convenience and safety of buildings. These includes mechanical, electrical, plumbing, lighting and security respectively (Wael & Weldy, 2020). The performance of building services from cradle to grave depends on effective design, installation and maintenance (Cheshire & Maunsell, 2017). Non-automated building services are mechanical, electrical and plumbing (MEP) systems that run, adjust and control by human beings without the use of sensors and computer control. It is the most common approach of installing building services in both residential and public buildings. This is because non-automated building services offers less investment in hardware and software and are more flexible allowing for adjustments and changes especially for smaller building applications (Wang & Liu, 2020).

Study conducted by Cheshire & Maunsell (2017) admitted that non-automated building services have shown tendency of limiting performance, functionality, efficiencies, increasing rate of mal-functioning and downtime that shortens the life span of equipment, labour intensive, prone to human error and may not be suitable for complex applications. Similar Study by Mensah and

Khedr, (2022) and Wang and Liu, (2020) admitted that, one of the ways of enhancing the optimal performance and efficiency of building services is to automate them during the design and operation phase.

Automated building services are MEP systems that runs with computer control. It makes use of advanced technologies such as building management system (BMS), building automation and control systems (BACS) and central control monitoring system (CCMS) to monitor, control and adjust building services equipment in order to optimize their performance, collate and visualize data to automatically generate reports, create alerts system when parameters are exceeded or when failures are likely to occur in order to exercise control (ISO, 2005; ISO, 2004). It is perceived as self-regulating technique for employing a computerized technologies to carryout numerous tasks with programme or software's that regulates their behaviour (Oke & Aigbavboa, 2017). It is an intelligent system that combines both hardware and software connecting heating ventilation and air conditioning, lighting, security to communicate using a single platform with the purpose of promoting energy efficiency, optimizing water consumption, safety, convenience, comfort of occupants and reduce maintenance costs (Ippolito et al., 2016). This is achieved by networking a plethora of sensors and components responsible for monitoring, reporting, optimizing, scheduling, fault detection, diagnosis, remote access, and tracking of electrical and mechanical systems (Su & Wang, 2020).

Furthermore, the integration of AI-powered generative design and Internet of Things (IoT) sensors in ABS is gaining attention, particularly in commercial hubs globally (United State Green Building Council, 2024). As ABS building infrastructure continues to develop in Nigeria, understanding the categories and features of ABS systems had become essential for optimizing building performance and ensuring users' satisfaction. Despite the growing importance of ABS, there is limited research focused on the characterization and features of these systems within the Nigerian context. In Nigeria, a study conducted by David (2019) admitted that ABS buildings are majorly found in urban areas like Federal Capital Territory and Lagos State, Nigeria. The study asserted that the major prevalence of ABS in use are in the area of close circuit television (CCTV) and plumbing systems. However, despite the increasing demand for ABS and the potential benefit associated with ABS which includes energy savings, improved security and safety of lives, enhanced comfort and convenience and increased productivity of workforce in buildings (Cyril & Modupe, 2022), there are still lack of dearth in literature on the prevalence of ABS in the study area.

The prevalence of ABS in Nigeria, particularly in urban centers like Abuja and Lagos, is increasingly recognized as a critical factor in enhancing building efficiency, safety, and sustainability. However, there is a significant lack of empirical data on specific categories and features of these ABS systems within these regions. The gap in knowledge of categories and features hampers the ability of stakeholders like architects, builders' and facility managers and policy makers to make informed decisions regarding the design, implementation, and maintenance of ABS technologies. Moreover, the rapid urbanization in Abuja and Lagos had led to unique challenges, including inadequate infrastructure, rising energy costs, and environmental sustainability concerns. These challenges necessitate a comprehensive assessment of the current state of ABS to identify existing gaps and opportunities for improvement. Existing studies have primarily focused on broader issues of ABS adoption and its energy saving abilities, but overlook the key features of ABS technologies in the context of Nigerian cities (Akinwumi et al., 2019; Ojo et al., 2020).

Additionally, without a clear understanding of the prevalence and effective band of various ABS, there is a risk of inefficient resource allocation and opportunities for enhancing building performance. Therefore, this study assessed the categories and features of ABS in selected Abuja and Lagos State buildings. The study identified the categories of ABS prevalence in selected buildings in the study area, assessed the effectiveness of ABS categories and features using MSI and also compare the perception of CEs and FMs groups in the study area with the target of providing critical insights into their current status and potentials for future upgrades of buildings. The study systematically fill the gap by assessing the various categories of ABS and their respective features by analyzing its component. The significance of this study is underscored by the need for improved energy efficiency and operational efficiency in Nigeria's building industry, as highlighted by recent initiatives aimed at promoting green building practices (Ogunbiyi et al., 2021). The study also provide a comprehensive overview detailing its features as a valuable resource for architects, engineers, builders and facility managers looking to incorporate these systems into their designs, enabling them to make informed decisions regarding approach. Understanding the prevalence and effective band of various ABS enhanced building performance in energy efficiency and improved occupant comfort. This is particularly crucial in the context of Nigeria's growing energy challenges and environmental sustainability goals.

Categories of Automated Building Services

Building services installations are devices that are usually integrated into buildings to provide comfort, safety, convenience and sustainable building designs. The areas includes plumbing systems that is concern with treatment and distribution for either cold water and hot water systems, sewage systems and drainage, other aspects of building services includes fire protection systems, electrical systems, security system, HVAC systems, electronics, telecommunication and mechanical transport system (Wael & Weldy, 2020). Similarly, electrical and mechanical service department (EMSD), (2002) admitted that for large buildings, the ABS process would cover general aspects of the building operations with an efforts to make buildings smarter focusing on reducing costs through streamlining building operations in the areas of air conditioning and lighting with the target of reducing the annual operating costs of buildings through effective monitoring and optimization HVAC, lighting control, security and access control, life safety control, vertical transportation (lifts/elevators), energy management, power distribution, telecommunications, communications within public spaces. Advanced building systems (2003) admitted that components monitoring and controls is one of the most common categories of building services. It further admitted that all ABS systems must meet specific requirements. As a result, each section of ABS is concerned with the control of such building services and the control algorithm of such components specifically intended to handle this process. Table 1 shows the categories of ABS available in buildings globally. The most significant and noticeable aspect of these set requirements ranges from increased comfort in buildings for the occupants living or working in the buildings and its inhabitants. Other areas significantly addressed is in the personal comfort, safety, productivity and movement of occupants.

Table 1: Categories of Automated Building Services

Categories of ABS	Typical Building Services
Climate control	HVAC, humidity and air temperature
Visual comfort	Artificial lighting, daylight monitoring (motorized blind/shutter) constants light control

Personal safety	Fire alarm, Gas alarm, Emergency sound system, emergency lighting, closed circuit television (CCTV)
Building security	Intrusion alarm, access control, access leak detection, CCTV, Audio surveillance
Transportation	Lift/Elevator, Escalator, Travelator
One way audio	Public address audio distribution and sound reinforcement systems
Energy management	Energy efficiency, peak avoidance, integrating Renewable energy source (RES)
Supply and disposal	Power distribution, Waste management, Fresh water/ domestic hot water and waste water
Communication and information exchange	ITE network, Private branch exchange (PBE), Intercom, WAN access, Wireless Access

Source: Advance Building System, (2003)

(a) Heating and air conditioning control

Historically, the origin of ABS commenced in the field of heating, ventilation and air-conditioning (HVAC). ABS uses the least common denominator of a particular unit, and these unit of control are located in similar zones within buildings based on differences in exterior conditions, user situation and cultural background. They can also be used to regulate single office area, zones in an open space or a complete floor. Climate control is dependent on three parameters: room temperature, humidity and air quality. Similarly, external lighting conditions affects the climate. These characteristics must be adjusted to match human physiognomy for comfort reasons. These suggests that a favourable environment within the space will necessitate a combination of several characteristics within a specific range. The ASHRAE defined a number of guidelines in (ANSI/ASHRAE, 2004).

(b) Ventilation control

Another significant ABS is the ventilation system. Human being will naturally requires the airflow of ventilation systems. Similarly, modern ABS had developed a growing use of air quality sensors such as the CO_2, radon, dissipated organic and gas which assist in extending the spectrum of measurements beyond just determining temperature and humidity for optimizing the volume, purity and velocity of fresh air intake within the building space (ANSI/ASHRAE, 2004).

(c) Lighting control

Another key ABS is lighting system, which provides visual comfort. This has a general influence on the building illumination conditions. Artificial lighting orders were simple implemented utilizing light switches and occupancy detectors. Other advance operatives involves scheduled lighting and scenes, such as lowering the light for a presentation in a room or turning the light on and off automatically based on the occupancy. These building services commands are primarily used, and the latency is greater than 400ms making it difficult to perceive the command to action relationship. Constant light control (CLC) refers to the adjustment of light levels a room. A typical lighting sensor control circuit includes CCL dimming of lamps and driving of sun blinds to reduce daylight. (ANSI/ASHRAE, 2004).

(d) Safety and alarm control

Another domain of ABS is the safety and alert system. This is concerned with personal safety of occupants and the handling of alarms both within and outside the structures. The primary functions of these services are constant monitoring of building limits and the generation of alarms for on and off normal situations. Alarms must be notified, and actions are carried out in a specific order. ABS protects individual with gas and smoke alarms, heat sensors and fire protection systems. Similarly, in addition to monitoring the circumstances to maintain personal safety, there are services that ensure the structural safety of the buildings. Intrusion detection system include audio surveillance, presence detectors, breaking glass detectors and closed circuit television (CCTV) as well as water leakage detectors. Similar examples of alarm notification includes police or fire station notifications, evacuation audio messages, closing fire protection doors, and activating emergency lighting. The technical criteria include providing safe system such as the fire protection systems, a typical IP Video surveillance system and a typical IP surveillance systems (ANSI/ASHRAE, 2004).

(e) Access and security control

This aspect of ABS provide access control and security to assist in granting or resisting the access of individuals to a building with the help of smart cards, finger print verification, access code, digital locks, biometric access control and sensor barrier. The system utilizes robust software, hardware and IoT devices to permit access to only those persons that are authorized. It is relevant to secures and permit building access, visitors tracking and identity verification of occupants in the buildings (ANSI/ASHRAE, 2004).

Similarly, Martirano and Mitolo (2020) study admitted that ABS is capable of adding more value to occupant's life, improve energy efficiency, reduce operational cost, enhanced occupant comfort, increased building safety and security among others by providing access to:

(f) Elevator control

This aspect of ABS involves the use of technology to manage optimize and operate elevators without human intervention. As occupants inputs their desired floor level on the touch screen, the system automatically assigns occupants to individual elevator car, it also utilize sophisticated algorithm to optimize provide elevator traffic access and flow with the target of minimizing waiting and increasing efficiency. The sensor based system also detects occupant presence, weight and movement to permit elevator to adjust its operation accordingly (Martirano & Mitolo, 2020).

(g) Plumbing and water management control

Water management systems also utilize advance technology to monitor, regulate and optimize water consumption. Automated plumbing services provide access to water monitoring water level, flow rates, water pressure, leaks detection and adjust flow rates to minimize losses and ensure efficient distribution of water in buildings (Martirano & Mitolo, 2020).

(h) Energy management system (EMS)

Automated energy management system uses advances technologies to also monitor, control, and optimize energy consumption and tracking utility bills. It measures real time energy usage, peak demand and energy wastage, it optimize the integration of lighting, HVAC and electrical installations for energy efficiency and analyze the energy data to identify areas of improvement and energy usage (Martirano & Mitolo, 2020).

(i) Parking management

Automated parking management system (APMS) is a high technology- driven solutions that optimizes parking operations, increase revenue for parking, enhance safety and users experience. It provide real time guidance to available parking spots, reducing congestions and search time for vehicles, enhances cashless payments option such as mobile payments or license plate recognition for efficient transactions. Monitor real time parking space occupancy, enabling data driven decisions on pricing, capacity and maintenance. It also provides security features such as CCTV cameras and license plate recognition to deter theft and to ensure safe parking environment (Martirano & Mitolo, 2020).

(j) Waste management control

Automated waste management control makes use of sensors and IoT devices to optimize and streamline waste collection, composition, monitor waste levels, streamline waste collection, sorting and disposal process. The device sorts waste into several categories, such as recyclables, organics and landfill waste. Similarly, the real time monitoring of waste generation, collection and disposal is achieved by optimizing waste collection routes to reduce fuel consumption and carbon emissions (Martirano & Mitolo, 2020).

(k) Technical and electronics control

This area of ABS entails the monitoring of technical equipment and installations in buildings, such as CHP and DC/AC converter. It also includes media control over FTTH, television, Internet and phone to send billing data as provided by the operator. They are used to monitor and control several process, including on/off, volume, temperature, pressure, humidity and air flow rate. They detect changes in the surrounding and respond accordingly, allowing for fast responses to promote ease and comfort (Martirano & Mitolo, 2020).

Materials and Methods

The study adopted a mixed-method design. The quantitative approach involves administering goggle online survey questionnaire to 50% of the four hundred and fifteen (415) targeted population from thirty four (34) control engineers (supply side) due to few number of identified ABS control engineers in the study area, fourty four (44) building operators/facility managers and three hundred and thirty seven (337) ABS users' (demand side) using simple random sampling from eighteen (18) identified ABS firms and 34 selected ABS buildings in Federal Capital Territory and Lagos State, Nigeria. The choice of 50% of 415 provide 95% confidence and 4.8% margin of error (p=0.5), similarly for the study where the population is split into groups (demand and supply side), 208 total sample size ensures each sub group have sufficient respondent for a valid statistics. The survey questionnaire shows 100% response from both groups. The question was developed based on a five Linkert scale. Responses was given to each statement using the five linkert-type-scale for which 1 = very effective to 5 = strongly ineffective. The responses was summed up across the 49 items for the facility managers group and 83 items for the control engineers group to produce a scores for each variable (CE instrument included technical sub-features). Mean score index was used to determine effective band for each items using the equation. $MSI = \Sigma (fx)/N$ where f = frequency, x = weight, N = total respondents, following Likert (1932). While, the qualitative approach involves conducting direct observation in the ten (10) purposively selected ABS buildings (residential and hotel buildings) with recent ABS features and provided access to the building was guaranteed. Table 3 shows the number of selected ABS buildings. The study was conducted using observation checklist for each selected building by the researcher, data was recorded and taken once through physical view and was recorded on the checklist for each of the selected buildings in the study area.

Table 2: Population and Sample Size of the Respondents

Group of Stakeholders'	ABS Stakeholders'	States	Population	50% Population	Total Sample Size
Supply Side	ABS Experts	Lagos	20	10	10
	(Control Engineer)	Abuja	14	07	07
Demand Side	Operators/ Facility	Lagos	34	17	17
	Managers	Abuja	10	05	05
	ABS Users'	Lagos	291	146	146
		Abuja	46	23	23
Total			415	208	208

Table 3: List of ten Purposively Selected ABS Buildings and Location

S/N	**ABS Buildings**	**Location of ABS Buildings**	**Building Type**	**Number of Buildings**
1	ABS Building I	Lagos	Residential	1
2	ABS Building 11	FCT	Hotel	1
3	ABS Building III	FCT	Hotel	1
4	ABS Building IV	Lagos	Residential	1
5	ABS Building V	Lagos	Residential	1
6	ABS Building VI	Lagos	Hotel Cinema	1
7	ABS Building VII	FCT	Residential	1
8	ABS Building VIII	Lagos	Hotel	1
9	ABS Building IX	FCT	Residential	1
10	ABS Building X	Lagos	Hotel	1
	Total			**10**

Results and Discussion

Categories of Automated Building Services Installation Prevalence

Table 4 shows the prevalence of ABS category and features installations as reported by control engineers group and facility management group. Security and safety systems (finger print verification, access cards, access codes, face verification CCTV, surveillance, security fence, and security doorbell and fire alarm control) and Electrical/Lighting features for central light, wall bracket, magic fire light, spot light, console light, back light such as dimming, occupancy, time and goggle assisted switches recorded 100% installation prevalence, confirming their status as the foundational ABS categories in the Nigerian ABS building environment. Mechanical services like heating, ventilation and air conditioning control recorded 94.1% prevalence. Automated plumbing water supply, sensor activated taps, dish washer, showers and wash hand basin recorded 88.2% prevalent; shading devices and utility billing recorded 64.7% prevalence which represents a moderate prevalence; Waste Management control including waste collection, sorting and treatment respectively recorded the lowest prevalence at 35.3%, indicating it remains a nascent and underdeveloped ABS sub-domain in the study area.

Other least areas of ABS categories prevalence as indicated by the respondents are in the areas of real time data collection and measurement, monitoring and control, home electronics control, energy management, stairs control, refrigeration and water cooling control respectively. This findings was contrary to the result obtained by David (2019) where the study admitted that plumbing and security (CCTV) is most prevalent ABS in the study area. This signifies that recent ABS buildings emphasis more on lighting aesthetics features, goggle assisted switches and security and access control features for ease use of buildings in the study area.

Table 4: Categories of Automated Building Services Prevalence: Control Engineers' Group (n=17) and Facility Managers Group (n=191)

S/N	ABS Category	Sub-categories Included	Firms Installed (n)	Prevalence (%)
A	Mechanical (HVAC)	Air Conditioning, Ventilation, Heating, Hot Water, Elevator/Lift	16	94.1%
B	Electrical & Lighting	Lighting control, Energy management, Electronics, Technical control	17	100.0%
C	Security & Safety	Fire safety, Security systems, Access control, Alarm systems	17	100.0%
D.	Plumbing Control	Water management, Waste water, Water cooling/chilling, Parking	15	88.2%
E.	Shading / Utility Billing	Shading devices, Utility billing automation systems	11	64.7%
F.	Waste Management	Waste collection, Sorting, Recycling automation systems	6	35.3%

Figure 1 shows the mean score index across the 49 ABS features, the grand mean was M=3.86 (SD = 1.06), placing overall ABS feature effectiveness firmly within the Effective band. Top-performing features were Mechanical Control (M = 4.18, Effective), Air Conditioning (M = 4.07, Effective), and Occupant Tracking/Security (M = 4.02, Effective). Similarly, the moderate performing features were fault detection and maintenance (M= 3.99, Moderate), Comfort and Convenience (M =3.98), Temperature Control (M = 3.97) and managing access to buildings (M = 3.95) as shown in Table 5. Consequently, among all features, no individual variables fell below M = 3.70, indicating uniformly positive assessments of ABS features effectiveness across all sub-categories from the operational users' perspective. The high internal consistency of this scale (alpha = .975) validates the reliability of these ratings.

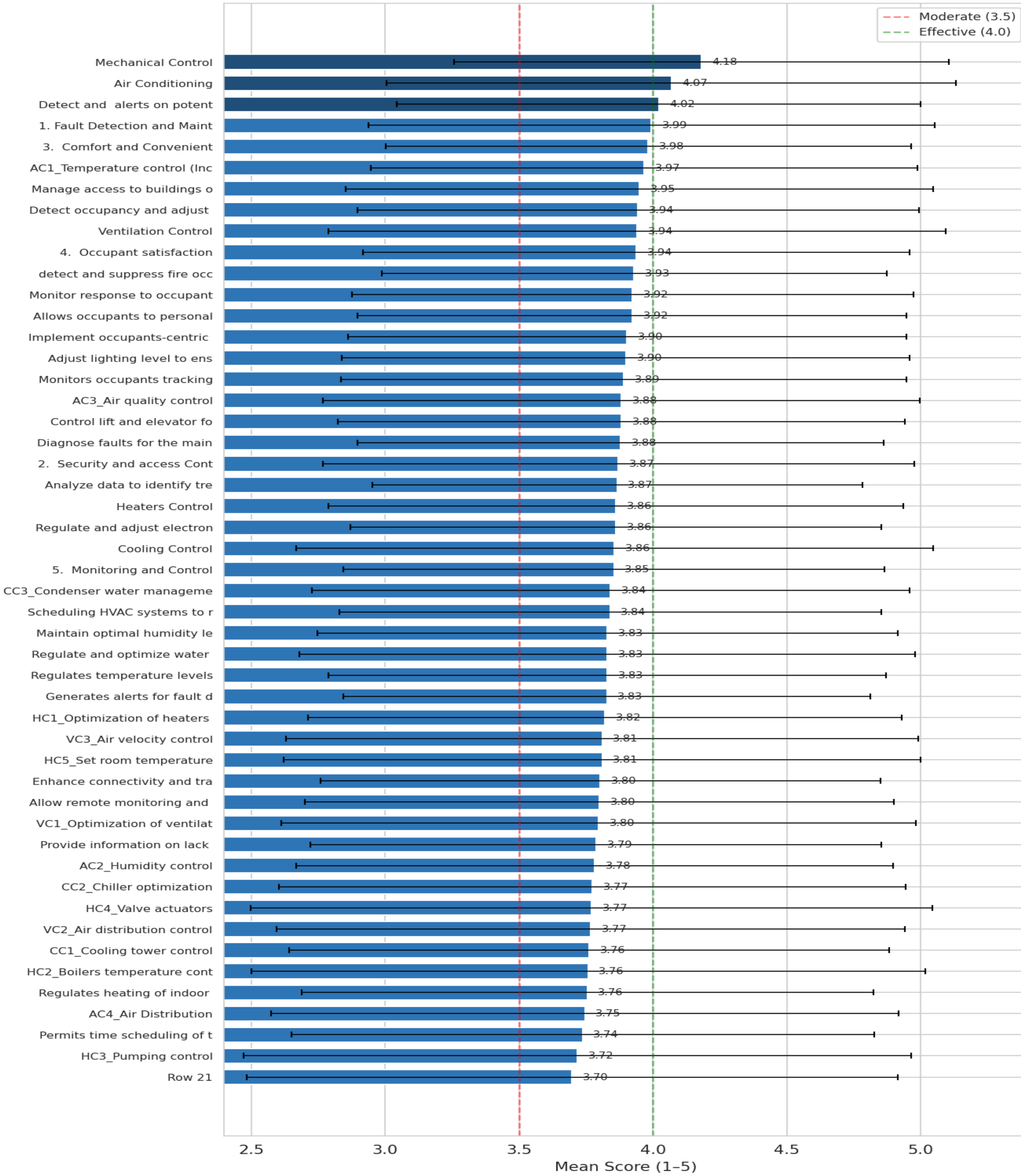

Figure 1: MSI of ABS Feature Effectiveness-Facility Manager Group (n=191). Error bars indicate +/- 1 SD

Table 5: Mean Score Index of ABS Features: Facility Manager Group (n = 191), Top 10 and Grand Mean

ABS Feature Category	Mean (M)	SD	Rank	MSI Interpretation
Mechanical Control (overall composite)	4.18	0.97	1	Effective
Air Conditioning temperature Control	4.07	0.98	2	Effective
Occupant Tracking and Security Systems	4.02	1.05	3	Effective
Electrical and Lighting Control	3.98	1.01	4	Effective
Energy Management and Monitoring Control	3.94	0.99	5	Effective
Ventilation Control	3.91	1.02	6	Effective
Fire Detection and Safety Control Systems	3.88	1.06	7	Effective
Plumbing and Water Management	3.82	1.08	8	Effective
Security Access and Intrusion Detection	3.78	1.07	9	Effective
Heaters, Boiler and Hot Water Control	3.72	1.09	10	Effective
GRAND MEAN (All 49 Items)	3.86	1.06	--	Effective

Note. MSI Scale: 1.00-1.79=Not Effective; 1.80-2.59=Fairly Effective; 2.60-3.39 = Moderate; 3.40-4.19=Effective; 4.20-5.00=Very Effective (Likert, 1932)

Figure 2 shows the mean score index across the 83-items with grand mean M = 3.611 (SD=1.29), also within the Effective band, but 0.25 points lower than the FM group. The category level MSI hierarchy revealed critical divergences from the FM group perspective and small (n) increases variance. Security and safety features achieved the Very Effective Threshold (M=4.424), the only category to do so across either group, driven by access control (M = 4.56), surveillance cameras (M=4.53), and access card verification (M=4.53). Similarly, electrical and lighting features (M =4.095); plumbing control features (M = 3.871) both achieved Effective Threshold respectively. In contrast, waste management (M = 1.906) and shading devices (M=2.246) fell into the Fairly Effective Band, indicating significant supply-side engineering capacity gaps in these sub-domains as shown in Table 6. The Moderate rating for Mechanical/HVAC features (M = 3.344) below the FM group's Effective band for the same category (M=4.18) representing a critical supply-demand gap with implications for HVAC commissioning quality.

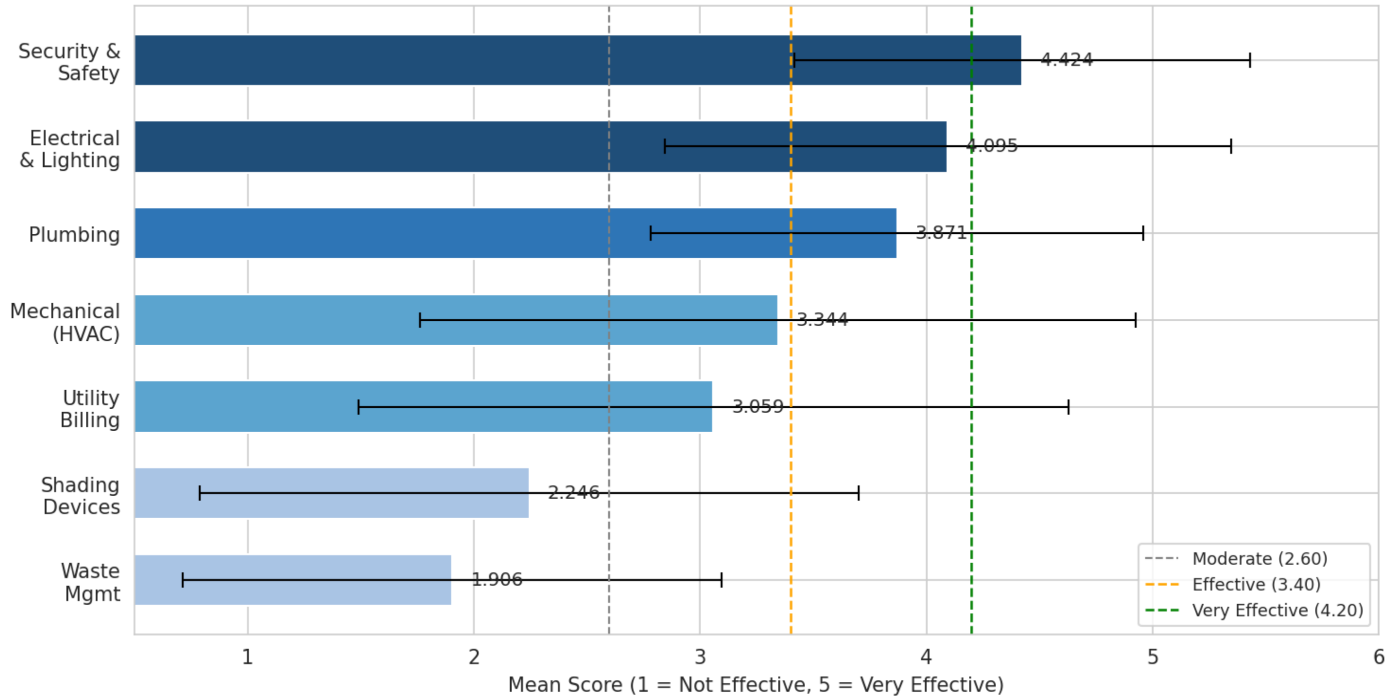

Figure 3: Mean Score Index of ABS Feature Categories- Control Engineering Group (n=17). Error bars indicate +/-1 SD. Dashed line = Effective threshold (3.40)

Table 6: Category-Level Mean Score Index of Automated Building Services Feature Effectiveness. -Control Engineering Group (n = 17)

ABS Category	No. Items	Mean (M)	SD	Rank	MSI Interpretation
Security and Safety Systems	17	4.424	1.006	1	Very Effective
Electrical and Lighting Control	13	4.095	1.252	2	Effective
Plumbing and Water Control	5	3.871	1.089	3	Effective
Mechanical Control (HVAC)	20	3.344	1.582	4	Moderate
Utility Billing Automation	5	3.059	1.569	5	Moderate
Shading Devices Control	7	2.246	1.456	6	Fairly Effective
Waste Management Automation	5	1.906	1.191	7	Fairly Effective
GRAND MEAN (All 83 Items)	83	3.611	1.288	--	Effective

Note. MSI interpretation per Likert (1932). CE respondents applied supply-side technical criteria, producing generally more conservative ratings than FM operational assessments.

Figure 3 illustrates, both groups rated ABS features within the Effective Band at the grand mean level, though with a consistent (0.25) point differential (FM/ABS users': M=3.86 VS CE: M=3.61). This differential is attributable to the more technically stringent evaluation criteria applied by supply-side engineering professionals, who assess ABS against optimal system specifications rather than operational users' experience. The most theoretically important divergence is in the HVAC/Mechanical category: FM respondents rated it Effective (M=4.18) while CE respondents rated it only Moderate (M=3.344). This supply-demand gap suggests that Facility Managers perceive HVAC automation as adequately meeting their operational needs, while Control Engineers recognized that advanced features: chiller optimization (M=2.18), condenser water management (M=1.82) fall short of technical best practice as shown in Table 6. This finding has direct implications for ABS procurement specifications and commissioning standards in the study Area. Analysis of open-ended responses corroborates these quantitative patterns: FM respondents frequently cited overall satisfaction with ABS functionality while noting isolated issues with predictive maintenance; CE respondents consistently highlighted interoperability limitations and the absence of advanced automation protocols in current installations as primary barriers to higher feature effectiveness ratings.

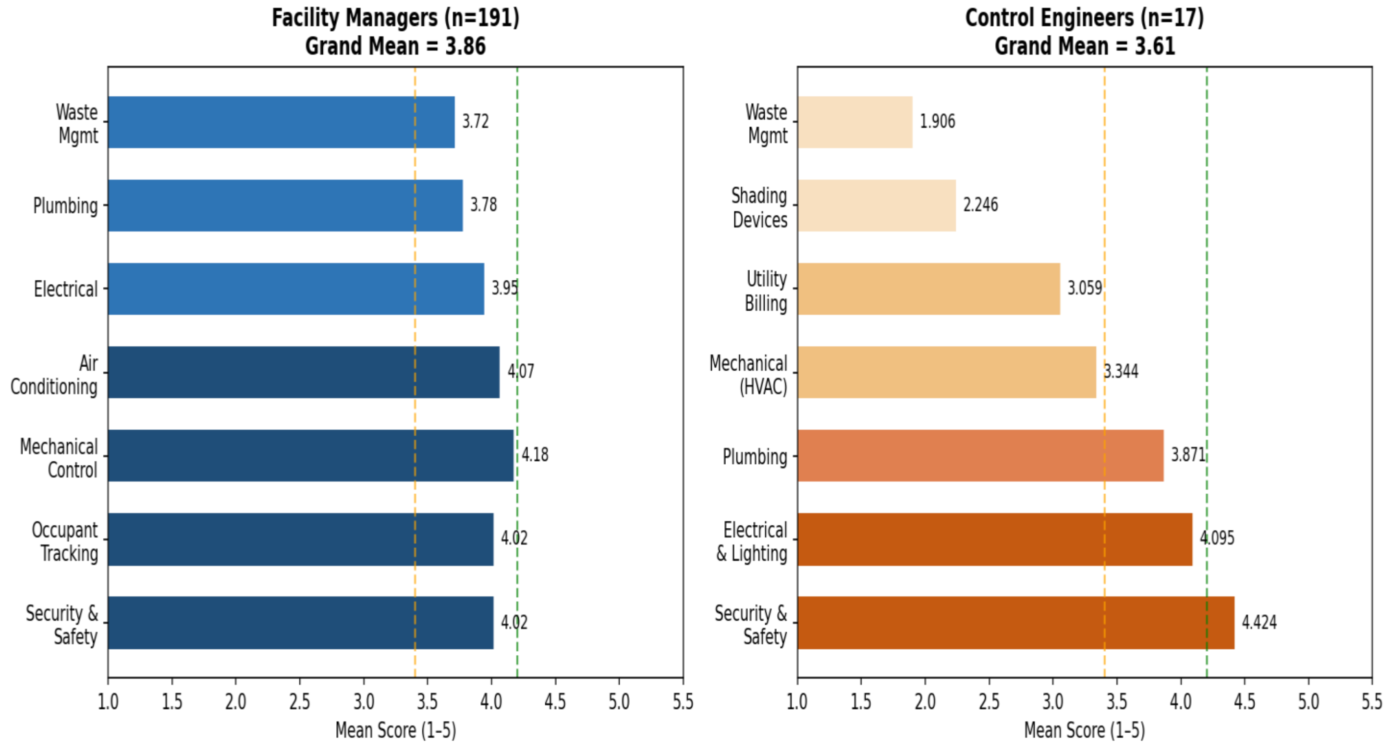

Figure 3: Comparative ABS Feature MSI by Category-FM (left panel) VS CE (right panel). Dashed lines indicate Effective (3.40) and Very Effective (4.20) thresholds.

4.2 Field Observation Conducted in Selected Automated Buildings in Federal Capital Territory and Lagos State, Nigeria (Qualitative Approach)

This section deduced the outcome of observation conducted on the ABS category and features of ten (10) purposively selected ABS buildings in the Federal Capital Territory and Lagos state, Nigeria. Door access, verification and authentication control into the buildings was one of the major ABS category with diverse features that either utilized finger print verification, smart cards, access codes, facial biometric and the use of conventional keys. For any occupants to access the building, the ABS access control verifies by authenticating any of the already existing captured face biometric, finger prints verification or access codes that could be authenticated before the accessing the buildings or makes use of the conventional keys.

The lighting control were also automated with diverse lighting fittings with variety of features for controlling the lighting, utilizing either mobile phone application, artificial intelligence (AI) voice command or central users interface to provide different lighting moods for the sitting and bedrooms areas. The lighting features consist of several varieties of light (central light, console light, back light, spot light and magic fire) which could be changed alternatively using AI voice assisted command to suite the occupants comfort and convinent. The AI voice assisted command or the central users interface could be used to either change the lighting mood to different background such as blue, red and green respectively for all types of lighting features. Similar AI voice assisted command and central users interface could be used to automatically control the on/off the varieties of lighting features (spot light, console light, back light and magic fire light) in the sitting area and rooms respectively. The AI voice assisted command for instance uses a command statement *"Alexa" put on the magic fire light, spot light, console light, back light respectively with the response "ok"* and the magic fire light, spot light, console light and back light automatically turn on obeying similar voice command.

The ABS buildings also control and adjust the air conditioning system to provide optimal temperature, humidity and air movement obeying either phone application, users' interface and "AI voice assisted command statement" with a command statement *"Alexa increase the AC temperature to 17^{O}C" with the response "Ok"* and the AC automatically sets to the required temperature. The required temperature could also be set and adjusted to several temperature between 17-25^{O}C depending on the external temperature Similarly, the ventilation control for the ABS building apartment also makes use of mobile phone application, voice command statements or the central users interface (CUI) to automatically control the ventilation system (standing fan). The ABS makes use of AI assisted voice command with *"Alexa" put on/off the fan with the response "ok"* and the fan automatically on/off. The fan could also be controlled automatically using the central users interface in the buildings. Consequently, electronic control of the ABS building apartment also uses mobile phone application, voice command statement and CUI to automatically control the television set using on/off or AI voice assisted command statements. The ABS could also controls and adjust the volume of the TV sets using similar AI assisted voice assisted command statements and users interface.

Curtain blind control also optimize and control the curtain blinds in the building using mobile phone application, AI assisted voice command statements, remote and CUI. Either of these three command could be use interchangeable to either open or close the curtain blinds. For instance, *"Alexa" open or close the curtain blinds, with the response "ok"* the curtain rail automatically open or close when the voice command is activated respectively. Subsequently, the ABS smart dishwasher released clean water when it sense human hand around the tap, once the hand is removed the tap automatically stop running. The smart infra-red hot plate/cooker utilized the kitchen platform to boil or cook, the cooker is digitally set to put on, before the boiling or cooking process commenced, once the boiling or cooking is completed the boiler automatically stops heating or boiling. Additionally, the kitchen ABS was designed to automate and control kitchen dishes and eating plate hanger obeying similar CUI and mobile phone application in the building. Any time the hidden kitchen dishes and plate hanger is required, the AI voice assisted command statement is used to open and close the hidden plate cabinets respectively. Observation showed that 5 of the 10 buildings used mobile app control, 7 of the ten used AI voice assisted command statement, 6 out of 10 used access card control, one used goggle assisted switch, 4 out of ten have CCTV cameras and very few buildings used remote control for curtain rail and gate control, 2 out of 10 used remote for gate access control. The observation results shows conformity with the reported survey results. Table 7 provides a detailed report of the ABS categories and feature prevalence of the 10 purposively selected buildings in Lagos and Federal Capital Territory.

Discussion of Results and Findings

The result revealed that the high percentage rating of security/lighting (100%) is likely due to insecurity in Lagos State and Federal Capital Territory and cost of electricity bills. Waste management with least percentage rating of 35.3% was also linked to lack of municipal smart waste infrastructure in the study area. HVAC gap in the study confirms facility managers' perceived HVAC automation as adequately meeting their operational needs, while Control Engineers recognized that advanced features: chiller optimization, condenser water management fall short of technical best practices. The National Building Code to mandate ABS for Class A buildings; provide capacity building through training for CE on chiller optimization and pilot of smart waste in Estates buildings in the study area.

Conclusion and Recommendation

The study concluded that both respondents group confirms the existence of identifiable ABS categories and features with measurable and statistically reliable effectiveness differentials. The category of hierarchy was consistent across groups with security/safety and electrical/lighting as highest; waste management and shading as lowest though the absolute MSI scores differs in both group perspectives. This hierarchy informs ABS procurement specifications and facility management KPIs in Nigeria context.

The study however recommends the followings:

(i) Prioritizing ABS security/safety and electrical/lighting categories by developing strategies giving their high rank score across groups of control engineers and facility managers' groups.
(ii) Longitudinal study on waste management and shading devices categories of ABS should be given attention to address gap by professional bodies with pilot study in Lagos State and FCT.
(iii) Further insight to inform decision making and optimize resource allocation for ABS features in the study area.
(iv) Standard Organization of Nigeria (SON) to adopt minimum ABS package: security, lighting, fire, HVAC for commercial buildings >1000 square meter.
(v) Training of facility managers on HVAC analytics to close gap with control engineers rating in the study area

Table 7: Categories and Features of Ten Purposively Selected ABS Buildings in Lagos and Federal Capital Territory

S/N	Automated Building	Categories of ABS	Features of ABS
1	ABS Building I	(i) Access control	Finger print verification, access code, RFID smart card and conventional key.
		(ii) Security control	CCTV camera, security fence (mobile phone application)
		(iii) Automated goggle-assisted switch control	13amp automated switch control (mobile phone application)
		(iv) Safety control	Fire alarm systems (Android phone application)
		(v) Lighting control	Occupancy sensor and timer switch control (mobile phone application)
		(vi) Air conditioning control	Temperature and humidity control (mobile phone application)
2	ABS Building II	(i) Access control	Door RFID access card
		(ii) Security control	CCTV camera: tracking and surveillance (central users interface and mobile phone application)
		(iii) Air conditioning control	Optimal temperature control (17^0C) (RFID access card)
		(iv) Electronic control	Television on and off control

		(v) Cooker control (vi) Boiler control	(RFID access card) Cooker control (RFID access card) Boiler control (RFID access card)
3	ABS Building III	(i) Elevator control (ii) Security control (iii) Access control (iv) Bell recognition (v) Safety control	Control (door mat sensor at 0.35radious: access floor level: voice command statement) Automated CCTV cameras: Tracking and surveillance (users interface) Door RFID access card Alert notification: sign and symbols (voice and language command) Fire alarms (smoke detector) using sound or voice alarm
4	ABS Building IV	(i) Access control (ii) Video bell control (iii) Security alarm (iv) Lighting control (v) Air conditioning control (vi) Electronic Control (vii) Curtain rail control	Facial recognition, finger print verification, password and conventional key Visual bell command: signs and symbols (central users interface or mobile phone application) Armed building (voice sirens (central users interface and android phone application) Central and moving light: ambient beautification(voice command) Temperature and humidity control: 17-25^{O}C (voice command) Television on/off (voice command and android phone application) Curtain blind on/off (voice command and android phone application)
5	ABS Building V	(i) Access control (ii) Lighting control (iii) Ventilation control (iv) Electronic Control (v) Curtain blind control	Curtain blind on/off (voice command and android phone application) Facial recognition, finger print verification, password and conventional key Control Lighting mood: central, console, magic, and pot light: Blue, Red and Green) voice command Air distribution (voice command) Television on/off (voice command) Curtain blind open/close (voice command)
6	ABS Building VI	(i) Access control (ii) Lighting control (iii) Air conditioning control (iv) Automatic voltage regulator (AVR) control	Door access code and access card Different lighting mood: setup or shutdown lighting mood (voice command) Temperature and humidity control (AI voice assisted command) Television, decoder and audio sets: movie mode or non-movie mode (voice command

7	ABS Building VII	(i) Gate access control (ii) Door access control (iii) Lighting control (iv) Electronic control (v) Air conditioning control (vi) Curtain blind control	Access for vehicle (remote control or android phone application Door RFID access card, finger print verification, password and smart key Dimmed light features: bracket, spot and central light (voice command, central users interface and mobile phone application) Television set: on/off (voice command, central users interface and android phone application) Temperature and humidity 17-24ºC (Voice command, central users interface and android phone application) Curtain blind: open/close (voice command, central users interface and android phone application) Remote and mobile phone application
8	ABS Building VIII	(i) Gate access control (ii) Door Access control (ii) Lighting control (iv)Curtain blind control (iv) Electronics control (v) Air conditioning control	Finger print verification, codes and RFID smart card control Voice command statement (on/off lighting mood and wall brackets) Voice command statement (open or close blind) Voice command (on/off television set and volume control) Voice command (control and adjust temperature) Central users interface and Android phone application (on/off light)
9	ABS Building IX	(i) Lighting (ii) Security and access control (iii) Electronic control (television) (iv) Water management control (v) Cooker and kitchen utensils hanger control	Android phone application Security Camera (lock or unlock RFID access card) Android phone application (on/off control) Smart water control On/off digital control cooker (smart button) and AI voice assisted command statement (open/close kitchen utensil hanger). Face biometric and RFID access card control
10	ABS Building X	(i) Door access control (i) Security control (iii) Water management control (iv) Air conditioning, (ii) Lighting (iii) Smart infra-red hot plate (iv) Television control	CCTV, Hikvision IDS DVR and security fence installations Sink, wash hand basin, and shower\ On/off RFID smart card control On/off RFID smart card control On/off RFID smart card control On/off RFID smart card control

Source: Adeleke et al., 2026

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