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Artificial Intelligence: Awareness and Adoption for Effective Facilities Management in the Energy Sector

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Abstract—Most sectors of the Nigerian economy, including the energy sector, have been infiltrated by digital technologies, including artificial intelligence (AI), where they have been extensively investigated. The research aims primarily to assess the perception of AI in facility management and identify the prospects and challenges of the adoption of AI in the energy sector. The study adopted the quantitative methodology approach, using a structured questionnaire to a sample size of 384 respondents. The questionnaire was administered to professionals such as mechanical, civil, electrical, computer, and mechatronics engineers and project managers within the North-central geopolitical zone of Nigeria. Data gathered was analyzed using descriptive analysis (mean value, weighted total, and relative importance index). The study based on findings concludes that there is a high awareness level about AI in the energy sector. Also, awareness about some selected AI technologies, machine & deep learning, robotics, and speech recognition had a high awareness level. The study also concludes that improved energy management, efficiency and transparency, remote reading of energy meters, and improved planning, operation & control of power systems were prevalent prospects of AI adoption. The major challenging factors to adopting AI in the Nigerian energy sector are outdated power system infrastructure, cellular technologies, a scarcity of qualified experts and data scientists, and a growing threat from cyber-attacks. The study recommends improved awareness and technical know-how of energy sector personnel and adequate power system infrastructure to provide a stable power supply.

Keywords—Artificial intelligence, Awareness, Energy Sector, Facilities management

1 Introduction

Artificial intelligence (AI) is a type of "deep learning" that enables machines to analyze information on a very sophisticated level on their own, allowing them to perform complicated functions such as facial recognition and speech recognition [1]. According to [2], AI systems can quickly extract insights from massive, heterogeneous data sets and discover correlations that might otherwise go missed by humans. As a result, AI is a powerful tool for improving people's daily lives [3]. From self-driving cars and industry automation to smart home apps like Siri and Alexa, AI has significantly impacted society [4]. AI has become one of the most advanced technologies used in numerous industries in the twenty-first century. The primary motivation for implementing AI is to combine multiple areas like medicine, renewable power, and education [5].

Artificial intelligence is commonly employed for solar power plant irradiance prediction and estimated power output, as well as wind speed prediction and projected power output from wind farms [4]. Recently, end-to-end technology such as artificial intelligence robotics and wireless communications have been developed and widely used for energy digitization [6]. The utility business is undergoing a shift from a steady environment to a volatile, technology-driven environment [7]. Hence, AI in collaboration with other technologies can be effective instruments for resolving issues and supporting key stakeholders in making complex decisions during power networks' planning, execution, and maintenance phases. Furthermore, the advanced application of AI in the power sector is crucial in smart-grid set-ups, notably timely fault discovery and enhanced forecast for renewable energy [8]. According to [9], artificial intelligence can help the energy business capitalize on the expanding opportunities created by digital technologies and the incorporation of renewables. Energy generation, distribution, and finances required are critical to the global economy [4]. These cannot be achieved with the present electrical grid infrastructure, which is outdated with insufficient fault protection. AI advancements are revolutionizing the energy business the emerging technologies. AI has been utilized to accomplish a wide range of tasks, leading to improved performance of the sector [10]. [6] made a detailed description of some tasks of AI in the Energy Industry (see Figure 1).

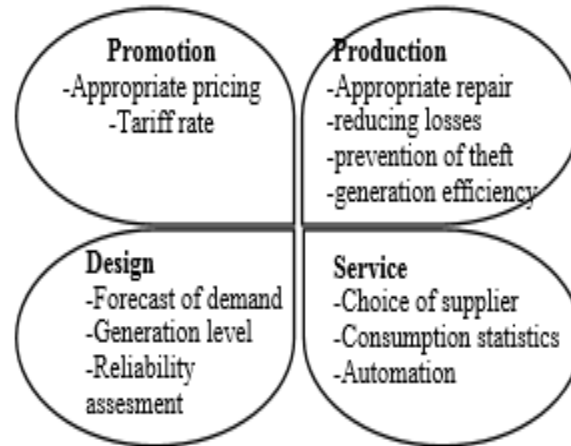


Fig. 1: Tasks of AI in Energy Industry [6]

Application of AI in photovoltaic (PV) systems improves inverter management and increases the ability to track power points [11]; [12]; [13]. Artificial maximum power point tracking (MPPT) techniques are more operational and can increase output when compared to regular MPPT processes [14]. AI systems, when correctly created, can be especially valuable for automated routine and structured procedures, allowing humans to deal with tomorrow's power concerns. The ability to provide clean, affordable energy, which is critical for sustainable development, is inextricably linked to AI [15]. AI and machine learning (ML) methods such as the Artificial Neural Network (ANN) and Random Forest (RF) are computationally efficient and accurate in forecasting energy consumption, cyber-attack, predictive maintenance, and facility management [16];[17]; [18]; [19].

Most developed countries have used artificial intelligence to grow every aspect of their economies to become world powers. Although we now live in a time when AI is taking over many jobs, almost everything in Nigeria is done manually [1]. Unstable supply and demand, inefficiency, and a lack of critical analysis essential for optimal administration pose new challenges to the energy sector [15]. Despite its relevance and progress in terms of innovation, AI has experienced several difficulties, particularly in developing countries such as Nigeria. Complex algorithms, AI human interface, cultural and religious barriers, software malfunction, and a decline in investment are some of the challenges identified by [1]. AI concerns can be solved systematically by transferring expertise from the power sector to AI software firms [15]. Some people believe that if Artificial Intelligence (AI) continues to advance unabated, it will threaten humanity. Others believe that, unlike previous technological revolutions, Artificial Intelligence (AI) will increase the risk of mass unemployment. This implies that artificial

intelligence is involved in the project of developing machines endowed with human-like cognitive processes and attributes such as reasoning, seeking answers, or learning from previous scenarios [1]. Similarly, Artificial Intelligence can be used to shape the growth of key sectors in the Nigerian economy. Indeed, the applications of AI technology will be the best technology for boosting core sectors and assisting Nigeria in its rapid digitization [1]. According to [6], the employment of artificial intelligence in the power industry will reduce power supply interruptions. [20] underlined that numerous opportunities such as digital progression and national development by adopting information and communication technologies (ICTs).

Empirical findings revealed that [5] highlighted the AI technologies adopted in power systems. [21] investigated how artificial intelligence impacts the solar photovoltaic value chain. Research [22] in their study explored the drawbacks, future opportunities of solar energy in selected countries in Asia, Africa, and South America. [1] also studied the importance, challenges, and applications of artificial intelligence in Nigeria. [23] reviewed the relevance of Artificial Intelligence in Indian industries at present and to the future. Unlike the existing literature contributions, this paper assesses the awareness of AI in facility management and identifies the prospects and challenges of the adoption of AI in the energy sector. Furthermore, the identification of the opportunities and obstacles of using AI is presented empirically. The study further provides insights into AI's broad topic for successful facility management. This research would help build the groundwork for identifying new strategies, provide additional insight into managing complicated electrical set-ups through AI, and aid in decision-making.

2 Material and Methods

The study adopted the quantitative methodology approach. This method entails data gathering, which may be subjected to further quantitative analysis in a formal manner [24]. Furthermore, data analysis is significantly easier and less error-prone using this technique [25]. As a result, the authors used a questionnaire to collect primary data from a sample size of 384 using the Cochran's formula. This method was used since the research population could not be determined.

$$n_0 = \frac{z^2 pq}{e^2} \quad (1)$$

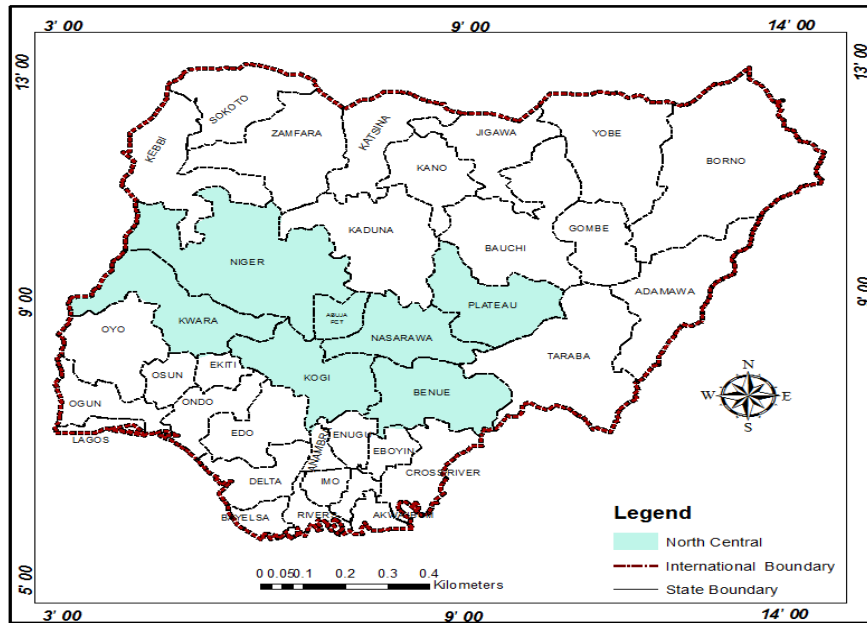
Where
e = .05
p = .5
q = 1 - p = .05
z = 1.96

Thus

$$n_0 = \frac{1.96^2(0.5*0.5)}{0.05^2} \quad (2)$$

$$n_0 = 384$$

The questionnaire was administered to professionals such as mechanical, civil, electrical, and mechatronics engineers, quantity surveyors, architects, and project managers within the North-central geopolitical zone (Plateau, Kogi, Kwara, Nassarawa, Niger States, Benue, and the Federal Capital Territory (FCT) Abuja) of Nigeria (see Figure 2). These professionals work with energy-oriented organizations within the study area. The choice of the North-central geopolitical zone was motivated due to proximity, convenience, and predominant economic development of the region. Additionally, Niger state within the zone has three hydroelectric power plants which distribute power supply to neighboring states.



The research instrument used for data collection was divided into three main sections. The first part asked respondents about personal details (such as; state, academic qualification, profession, organization category, and years of practice). The other two sections asked questions relating to the awareness of AI in facilities management and to identify the prospects and challenges of adopting AI in the Nigerian energy sector. The random method was the adopted Sampling technique, while Statistical Package for the Social Sciences (SPSS) was employed for descriptive analysis. Additionally, weighted index (WI) was further used for analysis to ascertain the level of awareness (WAI) of AI technologies and level of application. This approach was also adopted by [26] and [27].

$$WI = \frac{\sum_{i=0}^5 a_i x_i}{5 \sum_{i=0}^5 x_i} \quad (0 \leq WI \leq 1) \quad (3)$$

Where a_i = constant expressing the weight given to a group
 x_i = frequency of response

A value of WI approaching 1 signifies high respondent's agreement on variable factors measured. Hence, the higher the weighted total (WT), the higher the weighted index (WI), and the higher the level of agreement among respondents for a given variable factor.

3 Results and Discussion

3.1 Background data of respondents

The data analysis was based on 287 valid responses (74.7% return rate) retrieved from 384 administered questionnaires. The high response rate indicates the willingness of respondents to take part in the survey while the remaining 97 questionnaires were either incomplete or not returned and, as a result, were disqualified. The background data of respondents is presented in Table 1.

Table 1. Background data of respondents

Profile	Frequency	Percentage
Gender		
Male	193	67.2
Female	94	32.8

Academic Qualification		
NCE/ND	21	7.3
HND/BSC	138	48.1
MBA/MSC/M.Eng	84	29.3
PhD	44	15.3
Industry Professionals		
Project Manager	58	20.2
Electrical Engineer	62	21.6
Mechanical Engineer	47	16.4
Civil Engineers	48	16.7
Mechatronics Engineer	12	4.2
Computer Engineer	33	11.5
Other	27	9.4
Years of Experience		
1 – 5	42	14.6
6 – 10	46	16.0
11 – 15	75	26.1
16 – 20	77	26.8
Over 20	47	16.4

The results showed that males account for 67.2% while females account for 32.8%; this implies that there are more male industry professionals in the energy sector. The survey of the educational qualifications showed that 7.3% have NCE/ND, 48.1% have HND/BSC, 29%.3 have a master’s degree, and 15.3% had PhD; this indicates that the respondents have the fundamental and necessary educational credentials to offer response required to support the conclusions of this study. The respondents were further distributed as Project Managers (20.2%), Electrical Engineers (21.6%), Mechanical Engineers (16.4%), Civil Engineers (16.7%), Mechatronics Engineers (4.2%), Computer Engineers (11.5%), and others (9.4%). About 26.8% of the respondents had experience spanning 16 – 20 years while 14.6% had the least experience of 1 – 5 years. This further implies that industry professionals are experienced in their various fields and have also developed extensive expertise in handling industry-related challenges; as a consequence, the data gathered is reliable and appropriate.

3.2 Awareness of Artificial Intelligence (AI) in the Energy Sector

Figure 3 depicts respondents' understanding of the idea of Artificial Intelligence. According to the study's findings, most respondents (76%) had heard of AI, while 24%

had never heard of the notion. The findings might be ascribed to the current understanding of the notion through the internet, social media, television shows, and seminars, among other things.

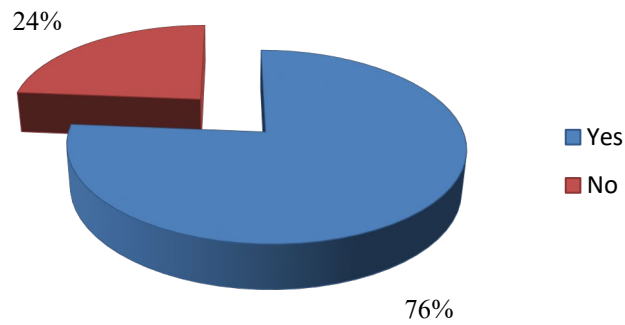


Fig. 3. Awareness regarding the concept of AI

Respondents were also asked to rate their level of awareness of a variety of AI technologies mentioned in the literature using a 5-points Likert scale, with "1" indicating the least level of awareness and "5" representing the highest level of awareness. Their level of awareness was ranked 'high' and 'low' using the respective mean score under each variable. The knowledge regarding AI technologies is presented in Table 2.

Table 2: Awareness regarding AI technologies

S/No	AI Technologies	1	2	3	4	5	Mean	Weighted Awareness Total	Weighted Awareness Index	Level of Awareness
1	Machine Learning	36	43	69	80	59	3.29	944	0.658	High
2	Deep Learning	50	47	46	86	58	3.19	916	0.638	High
3	Neural Network	78	71	62	54	22	2.55	732	0.510	Low
4	Expert System	63	71	72	61	20	2.67	765	0.533	Low
5	Fuzzy logic	87	73	56	40	31	2.49	716	0.499	Low

S/No	AI Technologies	1	2	3	4	5	Mean	Weighted Awareness Total	Weighted Awareness Index	Level of Awareness
6	Natural Language Processing	69	36	78	56	48	2.92	839	0.585	Low
7	Robotics	5	11	94	84	77	3.8	1030	0.718	High
8	Speech Recognition	27	47	95	75	43	3.21	921	0.642	High

1 = NA; 2 = SA; 3 = SWA; 4 = MA; 5 = EA

Further analysis using weighted awareness index (WAI) show the existence of high awareness of AI technologies such as robotics (0.718), machine learning (0.658), speech recognition (0.642) and deep learning (0.638) while natural language processing (0.585), expert system (0.533), neural network (0.510) and fuzzy logic (0.499) all have low awareness level as presented in Figure 4.

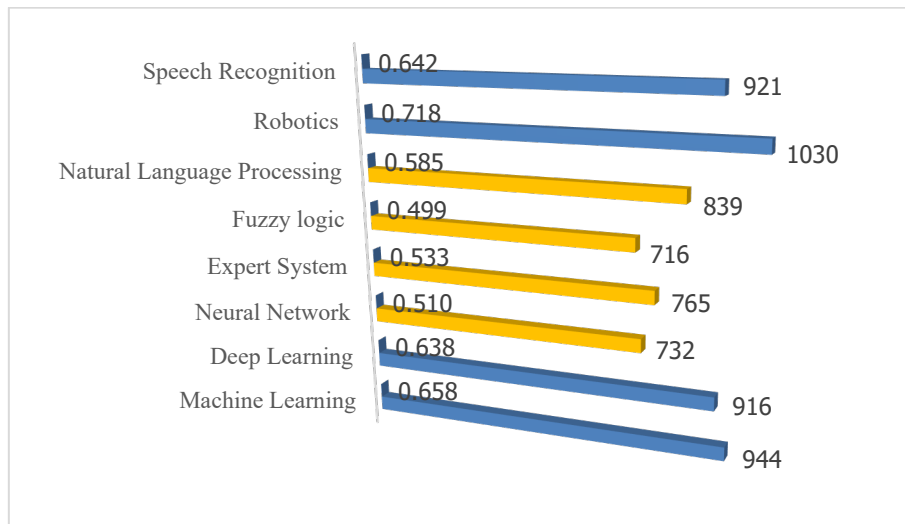


Fig. 4. Awareness level of AI technologies

To determine the level of knowledge of AI, respondents were asked to rank their level of awareness of AI applications in the energy industry. Table 3 summarizes the findings, categorizing the level of awareness as "high" or "low."

Table 3: Awareness regarding AI applications in the energy sector

S/No	AI Technologies	1	2	3	4	5	Mean	Weighted Awareness Total	Weighted Awareness Index	Level of Awareness
1	Digitalized Power Generation	42	39	80	69	57	3.21	921	0.642	Low
2	Advanced Metering Infrastructure	25	27	53	96	86	3.67	1052	0.733	High
3	Energy Storage Analytics	52	68	71	45	51	2.91	836	0.583	Low
4	Smart Grid	28	38	81	78	62	3.38	969	0.675	High
5	Network Management	29	35	69	76	78	3.48	1000	0.697	High
6	Energy Efficiency Decision Making	39	48	77	68	55	3.18	913	0.636	Low
7	Fault Prediction and Detection	37	50	56	75	69	3.31	950	0.662	High
8	Renewable Energy Forecasting	45	55	77	56	54	3.07	880	0.613	Low
1 = NA; 2 = SA; 3 = SWA; 4 = MA; 5 = EA										

The result using weighted awareness index (WAI) shows that there is a low level of awareness in AI's application in digitalized power generation (0.642), energy efficiency decision making (0.636), renewable energy forecasting (0.613), and energy storage analytics (0.583) among the respondents while the application of AI in advanced metering infrastructure (0.733), network management (0.697), smart grid (0.675) and fault prediction/detection (0.662) all registered a high level of awareness as presented in Figure 5.

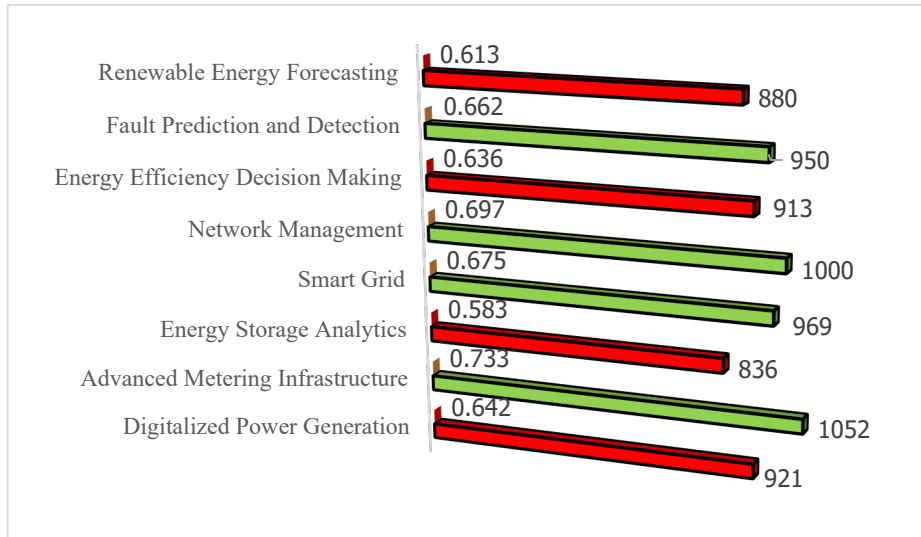


Fig. 5. Awareness level of AI Applications

The respondents were questioned if there is a personnel committed to or in charge of AI in their respective organizations. The results presented in Figure 6 showed that 86% do not have designated group/personnel responsible for AI in their organizations, while 9% have a dedicated group.

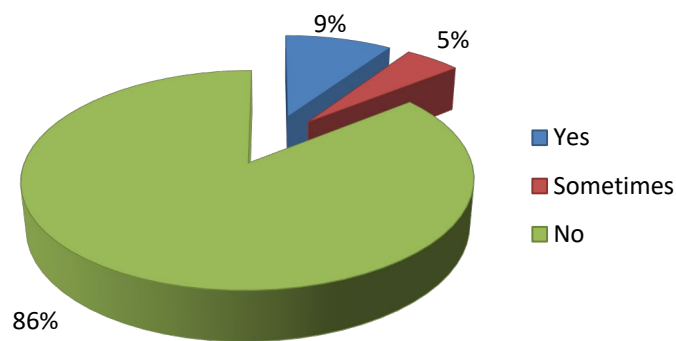


Fig. 6: Designated Group or Personnel Responsible for AI

3.3 Prospects of the adoption of artificial intelligence in the energy sector

Another objective of this research was to determine the prospects of AI in the energy sector. Extracts from the studies of [9]; [20] and [22], twelve prevailing prospects AI

may be useful to the energy sector was drawn. On a 5-point Likert scale, respondents were requested to view their opinion. Table 4 shows the prospect of AI adoption in the energy sector.

Table 4: Prospects of AI adoption in the energy sector

Prospects	1	2	3	4	5	Mean	Weighted Total	Weighted Index	Rank
Improved energy management, efficiency and transparency	10	19	37	124	97	3.97	1140	0.794	1
Remote reading of energy meters	10	15	48	117	97	3.96	1137	0.792	2
Improved planning, operation and control of power systems	18	19	43	110	97	3.87	1110	0.774	3
Improved forecasts of electricity demand and generation	10	24	57	101	95	3.86	1108	0.772	4
Detection and Prediction of Fault	15	24	40	114	94	3.86	1109	0.773	5
Power quality monitoring and renewable energy forecasting	12	24	54	103	94	3.85	1104	0.769	6
Automation of routine and structured tasks	15	23	58	102	89	3.79	1088	0.758	7
Improved reliability, security and efficiency of electricity transmission and distribution	19	34	33	107	94	3.78	1084	0.755	8
Prevention of losses due to informal connections and energy theft	20	25	59	97	86	3.71	1065	0.742	9
Encourage and hasten the adoption of clean renewable energy sources.	23	29	49	97	89	3.7	1061	0.739	10
Lower energy waste and costs	25	33	49	97	83	3.63	1041	0.725	11
Improved assessment of damages and disaster recovery	25	32	63	95	72	3.55	1018	0.709	12
1 = SD; 2 = D; 3 = N; 4 = A; 5 = SA									

Descriptive statistics using mean, weighted total (WT), and weighted index (WI) was used to analyse the identified prospects. According to the results, ‘improved energy management, efficiency and transparency’ (WI=0.794); ‘remote reading of energy meters’ (WI=0.792); ‘improved planning, operation and control of power systems’ (WI=0.774) ranked first, second and third respectively while ‘accelerate the use of clean renewable energy sources’ (WI=0.739); ‘lower energy waste and costs’ (WI=0.725); ‘improved assessment of damages and disaster recovery’ (WI=0.709) ranked tenth, eleventh and twelfth respectively. The results support [15]; and [14] that AI can potentially change contemporary energy systems and effective facility management in the energy sector. AI improves estimates of electricity demand and generation, allowing the demand-supply balance. Furthermore, artificial intelligence tends to minimize energy wastage, slash energy prices, and expedite the deployment of cleaner energy sources. AI may also aid in designing, operating, and controlling power systems.

3.4 Factors challenging the adoption of AI in the energy sector

Adopting and deploying AI in the energy sector presents a number of challenges. Eight common factors were identified from literature [22]; [15]; [1] to highlight the challenges associated with the adoption of AI, while others were identified via conversations with experts. The results presented in Table 5 is based on a 5-points Likert scale.

Table 5. Factors challenging the adoption of AI in the energy sector

Challenges	1	2	3	4	5	Mean	Weighted Total	Weighted Index	Rank
Outdated power system infrastructure	12	15	33	118	109	4.03	1158	0.807	1
Cellular technologies	15	19	37	113	103	3.94	1131	0.788	2
Scarcity of skilled professionals	18	20	29	115	105	3.94	1130	0.787	3
Growing threat from cyber attacks	14	24	36	112	101	3.91	1123	0.783	4
AI is dependent on electricity and internet connections	18	23	37	97	112	3.91	1123	0.783	4
Data quality issues	15	20	38	117	97	3.91	1122	0.782	6
Lack of dedicated AI policy and regulation	15	24	40	111	97	3.87	1112	0.775	7
Legal security concerns and user privacy	17	25	54	98	93	3.78	1086	0.757	8
The concept of AI models is unknown to users	18	26	54	101	88	3.75	1076	0.750	9
Integration of AI into subsystems	19	30	52	97	89	3.72	1068	0.744	10
Decentralization and diversification	25	32	57	94	79	3.59	1031	0.718	11

Possible job loss within the energy sector	28	31	54	96	78	3.57	1026	0.715	12
Generate questions on transparency	31	40	65	86	65	3.4	975	0.679	13
1 = SD; 2 = D; 3 = N; 4 = A; 5 = SA									

Similarly, descriptive statistics using mean, weighted total (WT), and weighted index (WI) were used to analyze the identified challenges. The findings showed that ‘outdated power system infrastructure’ (WI=0.807); ‘cellular technologies’ (WI=0.788); ‘scarcity of skilled professionals’ (WI=0.787); and ‘growing threat from cyber-attacks cellular technologies’ (WI=0.783) were the major challenges identified by respondents. In addition, ‘decentralization and diversification’ (WI=0.718); ‘possible job loss’ (WI=0.715); and ‘generate questions on transparency’ (WI=0.679) ranked lowest. According to [14], several factors prevent broader AI adoption, such as difficulties with data quality and legal issues. The findings from the study also corroborate with that of [28] and [29] who opined that AI is reliant on infrastructures such as energy and internet connectivity. There are few datasets accessible for AI projects, and the provided data is of uncertain quality. As a result, many targeted AI and ICT initiatives fail to offer the benefits requirement to the project's sponsors owing to incorrect and inadequate data.

Furthermore, in underdeveloped nations such as Nigeria, cities, outlying areas, and villages lack regular power supplies and reliable internet coverage. The lack of these requisite infrastructures poses a significant barrier to using AI in facility management in the energy sector. Furthermore, several countries are developing legislation and regulations to support the initiation and full adoption of AI-based technology, but this is not the case in Nigeria.

4 Conclusion and Recommendations

The study's primary objective is to assess AI awareness in facility management and to identify the prospects and challenges of adopting AI in the energy sector. Based on the data, the research finds a high level of awareness regarding the notion of AI in the energy sector. Also, awareness about some selected AI technologies, machine & deep learning, robotics, and speech recognition had a high awareness level. Additionally, the study concludes that AI technologies with a high awareness level regarding applicability to facilities management in the energy sector are in advanced metering infrastructure, smart grid, network management, and fault prediction/detection. The study also concludes that improved energy management, efficiency and transparency, remote reading of energy meters, and improved planning, operation & control of power systems were the most prevalent prospects of AI adoption. The critical challenges to AI deployment in the Nigerian energy sector are outdated power system infrastructure,

cellular technologies, a scarcity of qualified experts and data scientists, growing threats from cyber-attacks, and AI dependence on electricity and internet connections.

Hence, the study recommends the following:

1. *Improved awareness and technical know-how of energy sector personnel*
Increased awareness through conferences, workshops, and seminars for stakeholders in the power sector will boost the knowledge and awareness of AI-based technologies. These trainings would also enhance swift adoption when necessary infrastructures are provided.
2. *Provision of adequate power system infrastructure to provide stable power supply*
Most digital technologies, especially AI technologies, require an uninterrupted electricity supply for effective operation. Hence, unless the country is able to sufficiently address the issue of epileptic power supply, adoption of AI technologies will be impossible
3. *Provision of reliable connectivity in a rural underserved area for constant data communication*
Just like power supply, strong internet connectivity is another essential component of operating AI. Some urban cities and most rural settlements are still characterized by weak or very poor internet services, respectively. Hence, telecommunication providers need to improve and stabilize internet connectivity for enhanced AI adoption.
4. *Funding fundamental and applied research to produce significant breakthroughs in AI theory, technology, and applications in the energy sector.*
Adequate funding to support the massive infrastructural deficit to enable AI-technologies' active implementation and adoption cannot be overemphasized. In addition, research in the area of emerging AI technologies also requires funding to achieve breakthroughs in their applications.
5. *Setup secure platforms and databases to promote data quality and private data exchange*
Data security through secure databases to encourage investors and other stakeholders to venture into AI technologies in the energy industry cannot be overemphasized as well. This would curb the menace of cybercrime and boost confidence in AI operations.

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