Nigerian Perspective of the Potential for Energy Saving in IoT Systems

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Abstract

The generation and distribution of energy in Nigeria remain a challenge to date. Despite these challenges, energy wastage is still a major factor, such as security lights being left on even during the day. Certain factors were considered that lead to energy waste and disregard. One of which includes, irregular power supply. This paper focuses on the IoT and the opinions of several Nigerians from various demographics concerning their take on this technology and its applicability in their daily lives. It also aims to highlight the knowledge and acceptability of IoT technology for energy conservation. Five research question was answered alongside five tests of hypothesis to meet the aim of the study. The finding of the studies shows a significant difference in the level of awareness based on gender($p<0.004$). The respondent had a significant deviant perception of sometimes leaving their light on [$t(185)=3.7$ $p=0.00028$]. There was no significant effect of age groups on their acceptability of using the IoT to conserve energy at the $p<.05$ level for the conditions [$F(3,153) = 2.181$, $p=0.093$]. The study also found that there is no significant difference between Male and Female respondents concerning the assumption that the IoT will help conserve energy. There was a significantly deviant perception that the irregular power supply is a reason for forgetting to turn off appliances [$t(185) = -30.895$ $p = 0.000$]. Hence the study concludes that incorporating IoT devices into households can go a long way to salvage power mismanagement and energy conservation.

Keywords: *Internet of Things, Energy, Information and Communication Technology,*

1. Introduction

Nigeria is the most populous African nation with a population of over 160 million people (Akomolafe & Danladi 2014). Power generation and distribution have been a consistent challenge along with providing access to such power. Despite this, there is still a great level of energy being wasted from generation to distribution and also by clients in their homes, places of work, and leisure spots (Ogundipe & Apata 2013). This research aims to provide a view from a cross-section of those who have access to electricity with regards to energy wastage, possible causes for this wastage, and alternatives to saving the Internet of Things (IoT) to save energy.

The research explores the challenges faced by Nigeria concerning power generation and distribution. It also looks at the areas where electrical energy is lost or wasted to provide possible solutions to the IoT. An increase in processing speeds and storage capacities, coupled with cheaper devices and components are increasingly making the IoT more popular and easily accessible. This has led to the development of smaller devices that can communicate over the internet as Machine to Machine (M2M) communication, garnering information from environments and other devices (Stojmenovic, 2014).

The possible area of application of the IoT, to enhance electrical energy saving in Nigeria, is examined. The views and opinions of a cross-section of the population are obtained to confirm the acceptability of such technologies in Nigeria. This information is also analyzed to determine its acceptability for application as the view of the entire population.

This research begins by providing the reader with an overview of the power generation, distribution, and accessibility challenges in Nigeria, and is limited to electrical energy. It highlights the general population's access to electrical energy and the major source of this energy.

A look at the definitions and applications of the IoT is explored. This is to provide the reader with an outlook on the current applications of the IoT and how applicable it can be to Nigerian considerations. The percentage of the population with access to electrical energy is looked at. This is intending to provide the level of energy generation, consumption, and distribution. Next, the wastage and loss of energy are expanded for possible solutions to the challenges faced. This research also considered the standard bodies and organizations responsible for monitoring and dictating device standards for synergy and compatibility. This allows for the success of the deployment of IoT device communication protocols.

IoT architecture offers a professional view of how these communication protocols interact with various other layers for the success of the IoT. The two architectures elaborated on show various ways of approaching IoT design infrastructures. Attempts are made to answer the research questions objectively by analyzing the data collected through the use of a questionnaire. These questions are tailored to sample the opinions of Nigerians on their awareness of the Internet of Things, their position on energy wastage, and their acceptance of the Internet of Things. Conclusions are drawn from these analyses on the opinions of respondents.

Despite the inadequate generation, accessibility, and distribution of power, Nigeria still suffers from energy loss and power wastage. In households, appliances such as lights and other electrical appliances are often forgotten or left on for longer than necessary. This results in energy wastage, and higher unnecessary incurred costs for the consumer. Such resources can be better utilized and distributed more efficiently.

The study aims to evaluate the opinions of Nigerians concerning using the "Internet of Things" to conserve energy. To achieve the aim of the study we considered the following as objectives; firstly, we investigate the awareness of the Internet of Things. Secondly, we investigate potential causes of energy wastage. Thirdly, we examine the opinions of respondents concerning automated control for electrical appliances. Fourthly, we investigate the acceptability, and finally, we investigate the extent to which the irregularity of the power supply causes power wastage.

Government, estate developers, and private homeowners can apply the advantages obtainable by adopting smart solutions for homes. The research can also be used to provide vendors and producers of such devices with a view to the market share and potential for proffering such solutions to customers. Intending producers will also have an overview of the Internet of Things (IoT) architecture and bodies providing standards that can lead to more efficient products.

The scope of this study is focused on the use of electrical energy in the home. Other forms of energy are used in the home ranging from gas/kerosene/firewood for cooking but are not centric to this research. Information obtained from respondents was limited to online questionnaires, using Google Forms and WhatsApp or email for dissemination. This limits the opinions of respondents to those with email addresses and access to smartphones, PDAs, or computer systems with internet access. The limited amount of time and the unavailability of data is also contributing factor.

1.1 Research Questions

1. What is the awareness level of the Internet of Things?
2. How often are appliances and lights left on when they should not be?
3. What is the acceptability of using the internet of things to conserve energy?
4. Will the Internet of Things help in saving energy?
5. Is the irregular power supply a contributing factor that leads you to forget to turn off lights and appliances?

2. Literatur Review

The epileptic supply of electricity has been a major obstacle to Nigeria's economic growth Mojekwu (2021). The inadequate power supply has considerably hampered the growth of Small and Medium scaled Enterprises (SMEs) (Ogundipe & Apata 2013). The advanced and developed economies of the world are what they are due to a reliance on one source of energy or another (Akomolafe & Danladi 2014). Electrical energy inefficiencies can occur at any stage of the demand-supply chain. Unido (2006) states that the overall efficiency of a power plant does not exceed 30%. This buttresses the argument that energy losses can be significant from generation to the point at which it is consumed. Energy losses can be divided into two categories namely intrinsic and avoidable losses. Intrinsic losses are inevitable and have to do with thermodynamic laws of physics and avoidable losses have to do with poor design or wastage (Avci, Asfour, 2012, Unido, 2006).

Akomolafe & Danladi (2014) explained that Nigeria is a country with a population of over 160 million people with less than 40% of the population having access to electricity with an additional power loss of between 30% and 35%, this loss coming from old equipment, poor management and pilfering of parts. Ogundipe & Apata (2013) adds that over 45% of this loss occurs during transmission and that the Power Holding Company of Nigeria (PHCN) is functioning at a generating capacity of 27% with overstretched transmission lines. Since the major source of power generation is hydro, the fluctuation of water levels due to the dry season also hampers power generation.

In addition to the loss of power from transmission, this research was carried out to ascertain certain facts about power wastage from consumers as well, especially at the home, and the need or desire to curtail this wastage.

2.1 Theoretical Review

2.1.1 Internet of Things Definition

The IoT can be defined as a scenario where objects, sensors, and everyday non-computing objects are connected over the internet with computing capability. The connection to the internet allows these devices to communicate, exchange and generate data with minimal human intervention (Is, 2015). It has also been defined as the use of intelligently connected devices and systems to analyze and make use of data gathered by embedded sensors and actuators in machines and other physical objects (Gsma, 2014). Similarly, Katole, Sivapala & Suresh (2013). defined the Internet of Things as a network of interconnected objects that are uniquely addressable and connected using standardized communication protocols. In doing this, objects will be made smart and knowledgeable and can interact with their environment (Fraire, Céspedes, & Accettura, 2019).

2.1.2Standard Bodies of the Internet of Things

There is a general increase in the objects that are being fitted with devices for communication and data analysis. It is estimated that by the year 2020, 50 to 100 billion devices could be connected to the internet (Zeinab & Elmustafa 2017). According to Mehdi (2015), Machine – to – Machine (M2M) communication is expected to constitute up to 45% of the world's internet traffic. He explains that a report by the Mckinsey Global Institute states that the number of connected devices has grown by over 300% in the last five years. The success of the IoT is largely contingent on standardizing communication protocols for devices. This would provide reliability, compatibility, interoperability, and the ability to effectively operate on a global scale. There are more than 60 companies today, in communications and energy, working with standards such as the Internet Engineering Task Force (IETF), Institute *of Electrical and Electronics Engineers* (IEEE), and the International Telecommunication Union (ITU) to specify new Information Technology (IT) based technologies for the Internet of Things (Zeinab, & Elmustafa, 2017).

The IEEE Standards Association (IEEE-SA) has developed certain protocols that are related to the environmental needs of the IoT. It provides a foundation for the IEEE802.15.4 standard for short-range low-power radios, operating mainly in the scientific and medical band (Zeinab, & Elmustafa, 2017). They added that the IEEE-SA has over 900 active standards and more than 500 standards under development.

The European Telecommunications Standards Institute (ETSI) provides globally applicable standards for information and communications technology (ICT). This also includes fixed, mobile, radio, converged, broadcast, and internet technologies (Zeinab, & Elmustafa, 2017). She further explained that the standards are considered one of the basic standards of IoT due to their association with M2M communication, a basic technique related to IoT.

The Internet Engineering Task Force (IETF) is primarily concerned with the way the internet architecture is evolving and the unperturbed operation of the internet. It's open to the international community of network designers, operators, vendors, and researchers (Zeinab, & Elmustafa, 2017). She postulated that IETF has its description of the IoT providing a more recognizable enhancement to IPv6. The 6TiSCH Working Group is being formed at the IETF to enhance the networking pieces that will provide for more unified standards. Making use of open standards, 6TiSCH will provide a complete suite of protocols for distributed and centralized routing over the IEEE802.15.4e TSCH MAC. These protocols will boost the interconnection and communication of devices using low-data-rate, low-power, and low-complexity short-range radio frequency transmissions in a wireless personal area network (WPAN) (Bo, 2014).

2.1.3 IoT Architecture

Various architectures for IoT have been proposed as it gets more popular. Two popular architectures are the Three- and Five-Layer Architectures. This is shown in Figure 1.

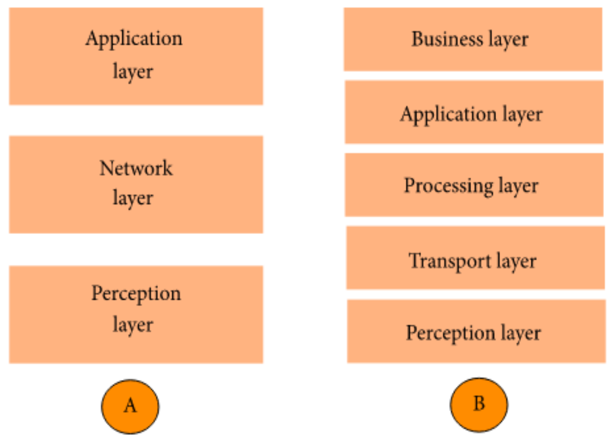

Figure 1: Architecture of IoT (A: three layers) (B: five layers) (Pallavi & Smruti, 2017)

The three-layer architecture, as the name implies, has three layers. Namely the application, perception, and network layers. In Figure 1, A represents the three-layer architecture. According to Sethi & SarangiR, (2017), the perception layer is the physical layer. This layer has sensors for sensing and gathering information about the environment. It can sense some designated parameters or other smart objects in the environment.

All communication and transmission of information between smart objects on a network and servers is the responsibility of the network layer. The third layer in this architecture is the application layer, which is responsible for delivering application-specific data to the user. It identifies the various areas in which the IoT can be deployed.

Pallavi & Smruti (2017) explains that the three-layer architecture provides the general idea behind the Internet of Things. He adds that the five-layer architecture is more detailed for research as seen in Figure 1. B. It contains the perception, transport, processing, application, and business layers. The application and perception layers are the same as the ones for the three-layer architecture. To avoid repetition, we outline the functions of the remaining three layers.

Pallavi & Smruti (2017) adds that the transport layer is responsible for moving the sensor data from the perception layer to the processing layer and vice versa via wireless, RFID, 3G, LAN, and Bluetooth.
The processing layer stores, analyses, and processes huge amounts of data that come from the transport layer. It manages and provides a diversity of services to the layers below it and can make use of many technologies such as cloud computing, databases, and big data processing components. The business layer, which is the fifth layer, manages all aspects of the IoT system. These include business and profit models, applications, and users' privacy.

2.1.4 Sensors and Actuators

To interact with the environment, all IoT devices must have sensors or actuators. Sensor technology makes context awareness possible in the IoT. These sensors need to be portable, have a low cost, and consume very little power. The major constraints of these sensors are battery life (Pallavi & Smruti, 2017, Arshad, Zahoor, Shah, Wahid, & Yu, 2017). Actuators on the other hand convert electrical energy to mechanical energy. It can also be considered as a special kind of transducer (Scme, 2011). Naser, Mahsa, Julian, & Behnam (2020) categorized actuators into four; firstly pneumatic actuators use compressed air to control processes that depend on the accuracy of the system response. Secondly, the thermal actuator generates kinetic energy from thermal energy in form of motion. Thirdly, Hydraulic actuators, generate mechanical operation/motion from the liquid. And finally, an electric actuator generates motion from external energy sources such as batteries.

2.1.5 Mobile Phone-Based Sensors

Smartphones are portable, ubiquitous, and have a lot of built-in data processing and communication capabilities. The growing use of smartphones has caused researchers to be interested in the use of these devices to propagate the IoT.

Smartphone sensors provide a great amount of data that can be analyzed to get meaningful results such as types of user motion (running, walking, jogging), presence of activity (by analyzing the phones of those in the same vicinity), and can be used to analyze human behavior (Pallavi & Smruti, 2017)

Pallavi & Smruti (2017) highlights the benefits of sensors in the medical field. The sensors can be used to measure and monitor various medical factors in the human body. Regardless of physical location, a patient can be monitored via these sensors as real-time feedback can be provided to doctors or required hospital personnel. Some of these devices are wearable, while others can be inserted into the patient (Poyner & Sherratt 2018).

Chemical sensors have a recognition element that is sensitive to stimuli produced by various chemical compounds (analyte) and a resultant signal is generated with the use of a transduction element that generates a signal proportional to that of the analyte (Praveen, 2010). These sensors are expected to play a critical role in environmental monitoring, both indoors and out. Environment sensors are used to monitor the parameters in the physical environment such as temperature, humidity, air pressure, water, and air pollution (Pallavi & Smruti 2017). He explains that these sensors can be used to measure air quality or the quality of food in a smart home.

The light sensor can have single optical sensors (photodiode, color sensors, IR and UV-sensors, etc.) that supply information on the light intensity, density, reflection, color wavelength, and the type of light (sunlight or artificial lights) (Schmidt & Van 2001). Various light sensors were studied which offered certain levels of sensitivity for certain wavelengths or color spectrums. The light sensors were seen to provide a rich source of information at a very low cost owing to the low cost of energy consumption and price (Schmidt & Van 2001).

2.2 Impacts of the Internet of Things

The applications of IoT continue to evolve and this evolution is a result of the expanding needs of clients. IoT is addressing societal needs and the advancements to enabling technologies such as nano-electronics and cyber-physical systems are consistently challenged by technical, economical, and institutional issues (Vermesan, & Friess, 2013).

Vermesan & Friess (2013) explains that by 2020 there is an expectation for Megacity corridors and branded networked and integrated cities. By 2025, there is an anticipation of at least 30 Mega Cities worldwide with a population of over 10 million people, and 55% expected in developing economies such as India, China, Russia, and Latin America. Vermesan & Friess (2013) adds that these cities are expected to be fitted with features such as Smart Economy, Smart Buildings, Smart Mobility, Smart Energy, Smart ICT, Smart Planning, Smart Citizen, and Smart Planning.

According to Jia, Komeily, Wang, & Srinivasan, (2019), smart cities can also be seen as digital or intelligent cities.

2.2.2 Smart Energy and the Smart Grid

There is a need for increased focus on our energy consumption behavior. Due to the undulating nature of supply, an intelligent grid would go a long way in reacting to power fluctuations by controlling electrical energy sources and sinks (Vermesan & Friess 2013). Network intelligent devices can be used for such functions and grid infrastructure elements. Vermesan & Friess (2013). explains that this will also require an in-depth knowledge of instantaneous device loads and consumer behavior patterns. A Smart Grid is expected to detect consumer needs and distribute energy as and when needed, thereby conserving energy. It could also be known as the Internet of Energy.

The energy here is expected to be packed like data packets and distributed accordingly. This would lead to resultant savings in energy where smart meters could provide users with instantaneous information on energy consumption and energy-wasting devices (Khatua, et al, 2019). The user could, in turn, eliminate the use of such devices or curtail their usage (Vermesan & Friess 2013). According to Patel & Patel (2016). detection of rubbish levels in containers can be used to optimize the collection routes. Rubbish bins with RFID tags allow garbage men to know what cans have been emptied and which need to be emptied more urgently.

2.2.3 Smart Homes

Smart homes generally refer to the use of intelligent monitoring systems that can detect when undesirable situations are occurring such as burglary or hazards (Song, Li, Mei, Yu, Xing, Cheng, 2017). The homes are usually equipped with embedded devices and can enhance the capabilities of everyday appliances. Examples of these include motion sensors, sensors in microwaves, lights, and smoke alarms (Dorri, Kanhere, Jurdak, Gauravaram, 2017, Juan, 2006). Energy and water use can also be monitored using sensors to conserve cost and resources (Patel & Patel 2016). For smart homes, Rushan et al (2017) discussed that e-CAB, a policy-based architecture, responsible for the evaluation of the efficiency of resource consumption of servers for the management of Data Centres has proven to reduce the energy consumption required to process data received from IoT devices. Machorro-Cano et al (2020) use the J48 machine learning algorithm and weka API to classify user behavior and energy consumption which target big data. Their proposal is titled the HEMS-IoT, a big data, and machine learning-based smart home energy management system for home comfort, safety, and energy-saving. The J48 machine learning algorithm and Weka API was used to learn user behaviors and energy consumption patterns and classify houses concerning energy consumption.

3. Methodology

A qualitative approach was used to gather the required data for analysis. An online questionnaire was created (using Google Forms) and passed around using a social media platform (WhatsApp). Here the respondents were required to answer a set of questions to find out their opinions on various aspects of power consumption, source, and usage. Their opinions were also solicited concerning their desire for the automation of some circuit controllers and lights.

3.1 Research Questions

What is the awareness level of the Internet of Things?
How often are appliances and lights left on when they should not be?
What is the acceptability of using the internet of things to conserve energy?
Will the Internet of Things help in saving energy?
Is the irregular power supply a contributing factor that leads you to forget to turn off lights and appliances?

3.2 Population

The random sampling technique was used with the aid of an online application for deploring the questionnaires. This provided for a wider reach of respondents across disparate geographical locations in Nigeria. Each sample also has equal representation. For this research, a questionnaire was passed around to random respondents' residents in Nigeria, to provide a view of what Nigerians think with regard to the IoT, its applications, and energy consumption habits. A well-defined population ensures that the information and analysis done provide a more accurate view of the feedback from a part of the population and the findings can be applied to the general populace in this area.

3.3 Primary Sources

Primary data was gathered from a part of the population that included both male and female respondents that uses electricity. The questionnaires were forwarded to adults randomly regardless of their knowledge of IoT as far as they use electricity in Nigeria. The primary data summarily includes the data collected by a questionnaire. Collecting this data has made it possible to view, analyze and provide resultant findings. For this study, information was gathered from 217 respondents with access to the internet and electricity.

3.4 Data Analysis Techniques

Qualitative data analysis was done using the Chi-Square Test, one sample T-Test, and the Independent two-sample T-Test, where applicable, using SPSS. The data was collected with the aid of Google's form which is an online questionnaire application that saves respondent responses in Google drive. WhatsApp social media tool was employed to disseminate the link to the questionnaire to potential adult respondents.

4. Result from Interpretation

The primary data collected is summarized. The qualitative data collected will be represented with the help of tables and brief explanations for the sake of clarity. Relevant relationships between variables will also be tested using statistical tools (Chi-Square and T-Test) toward providing results and answers to research questions.

4.1 Demographics

Of all the data collected, there are a total of two hundred and seventeen (217) respondents and one hundred and eighty–nine (189) are valid responses. There are 130(68.8%) male respondents and 59(31.2%) female respondents. Not all questions were compulsory therefore not all respondents submitted answers to all questions. Table 1 shows the demographics of valid respondents and their gender distribution.

Table 1: Demographics of respondents

		Frequency	Percentage (%)
Gender:	**Female**	59	31.2
	Male	130	68.8
		189	100

It is important to note that the geographical location of respondents was not taken into account as responses came from all over Nigeria.

4.2 Descriptive Data

An important area of analysis is the respondent's position on awareness of the Internet of Things (IoT). Table 2 provides the gender distribution of the respondents to the question, while table 3 presents the chi-square table.

1. **Research Question 1: What is the awareness level of the Internet of Things?**

Using the Chi-Square Test, we check to find out if there is a significant difference between Male and Female respondents with regard to their awareness of the Internet of Things.
H_0 is the null hypothesis where;
H_0 = no difference
H_1 = there is a difference
$\alpha = 0.05$

Table 2: Gender Distribution of awareness of the Internet of Things

		Have you ever heard of the Internet of Things?		Total
		No	Yes	
What is your gender?	Female	28	30	58
	Male	90	39	129
Total		118	69	187

Table 2 shows that out of the 58 female respondents that participated in the study, 30 (51.7%) have heard about IoT, while 90(69.8%) out of 129 male respondents have not heard about IoT. Overall, out of the total respondent, 187 about 118(63.2%) have not heard about IoT meaning only 69(36.8%). The result in table 2 has corresponded to the result in table 3 which rejected the null hypothesis, hence there is a significant difference between the level of awareness between males and females.

Table 3: Chi-Square Tests

	Value	df	Asymptotic Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	7.937a	1	.005		
Continuity Corrections	7.041	1	.008		
Likelihood Ratio	7.802	1	.005		
Fisher's Exact Test				.006	.004
Linear-by-Linear Association	7.895	1	.005		
N of Valid Cases	187				

a. 0 cells (0.0%) have an expected count of less than 5. The minimum expected count is 21.40.
b. Computed only for a 2x2 table

With p = 0.005, which is significantly less than $\alpha = 0.05$ ($p < 0.05$), we can reject the null hypothesis and state that there is a significant difference between Male and Female respondents with regard to their awareness of the Internet of Things as shown in Figure 2.

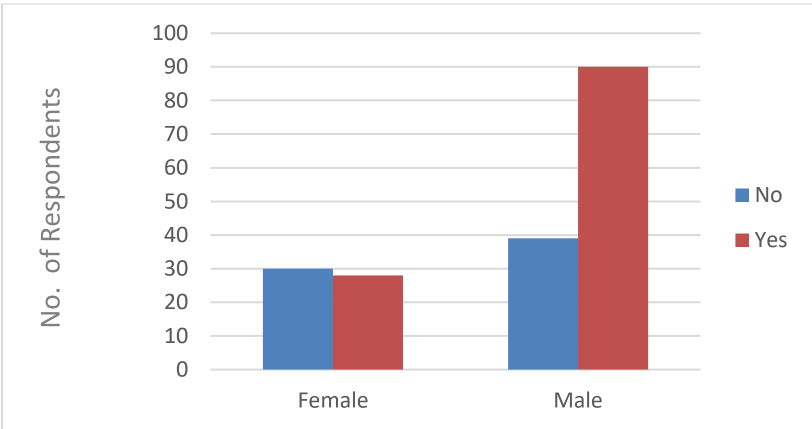

Figure 2. Male and Female respondents' awareness of the Internet of Things

2. Research Question 2: How often are appliances and lights left on when they should not be?
A one-sample T-Test was run to analyze an area of energy waste where respondents were asked about forgetting to turn off security lights. Table 4 shows the one-sample T-Test on how respondents often forget about security lights on
Question: How often do you forget the security lights on?
1 = Always, 2 = Often, 3 = Sometimes, 4 = Rarely, 5 = Never
Test the responses against $\mu = 3$
$\alpha = 0.05$

Table 4: One-Sample Test

	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
1. How often do you forget the security lights on?	3.706	185	.00027832	.301	.14	.46

Since $p < 0.05$ this test is significant. (the sample is significantly different from a $\mu = 3$).

People who were surveyed had a significantly deviant perception of sometimes leaving their lights on t (185) = 3.706 p = 0.00027832 as shown in Figure 3.

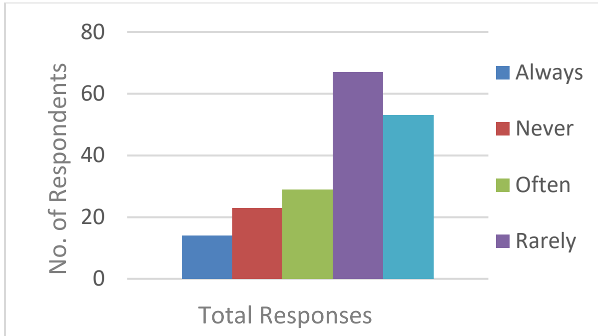

Figure 3. Respondents' opinions on how often security lights are forgotten.

3. Research Question 3: What is the acceptability of using the internet of things to conserve energy?

Would you like the option for lights and appliances to go off automatically if no one is in the room?

Key (Yes =1, No = 2, Maybe = 3)

Using the ANOVA test we check to find out if there is a significant difference between age groups and their acceptance of the IoT to conserve energy.

H_0 = there is low acceptability of using the IoT to conserve energy.

H_1 = there is high acceptability of using the IoT to conserve energy.

Table 5 provides an overview of the ANOVA Test.

Would you like the option for lights and appliances to go off automatically if no one is in the room?

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.576	3	.859	2.181	.093
Within Groups	60.226	153	.394		
Total	62.803	156			

There was no significant effect of age groups on their acceptability of using the IoT to conserve energy at the $p<.05$ level for the conditions [F (3,153) = 2.181, p =0.093].

We can therefore reject the null hypothesis H0 and conclude that there is a high acceptance for the IoT to conserve electricity as shown in Figure 4.

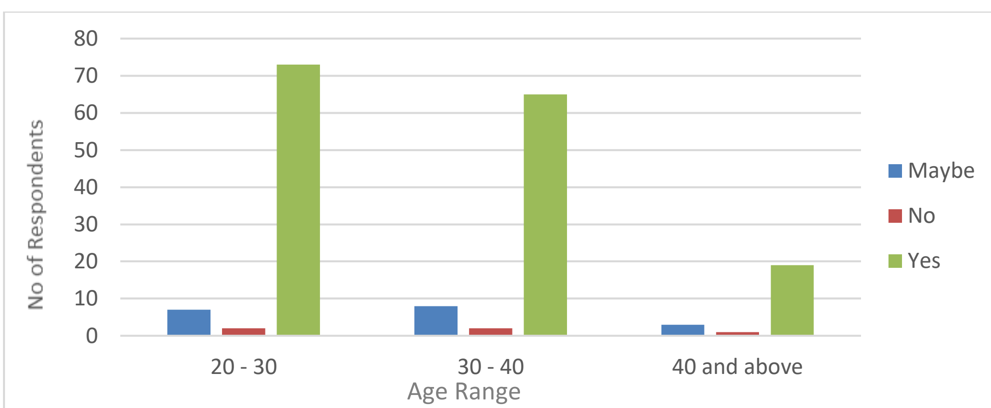

Figure 4. Acceptability of IoT based on age

4. Research question 4: Will the Internet of Things help in saving energy?

Using the Chi-Square Test, we check to find out if there is a significant difference between Male and Female respondents with regards assumption that the IoT will help conserve energy.

Key = ("Yes" = 1, "No" = 2, "Maybe" = 3)
H_0 is the null hypothesis where;
H_0 = no difference
H_1 = there is a difference
$\alpha = 0.05$
Table 6 shows the gender distribution with regard to the responses while Table 7 highlights the Chi-Square test results.

Table 6: Gender distribution on opinions for automation

			Do you believe that a level of automation on your appliances could help in the reduction of energy wastage?			Total
			1	2	3	
What is your gender?	Female	Count	48	2	8	58
		Expected Count	49.0	.6	8.4	58.0
	Male	Count	110	0	19	129
		Expected Count	109.0	1.4	18.6	129.0
Total	Count		158	2	27	187
	Expected Count		158.0	2.0	27.0	187.0

Table 7: Chi-Square Tests

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.502a	2	.105
Likelihood Ratio	4.737	2	.094
Linear-by-Linear Association	.020	1	.888
N of Valid Cases	187		

a. 2 cells (33.3%) have an expected count of less than 5. The minimum expected count is .62.

With $p = 0.105$, which is significantly greater than $\alpha = 0.05$ ($p > 0.05$), we can accept the null hypothesis and state that there is no significant difference between Male and Female respondents with regard to the assumption that the IoT will help conserve energy. This is clearly shown in Figure 5 which indicates a similar percentage distribution of male and female responses.

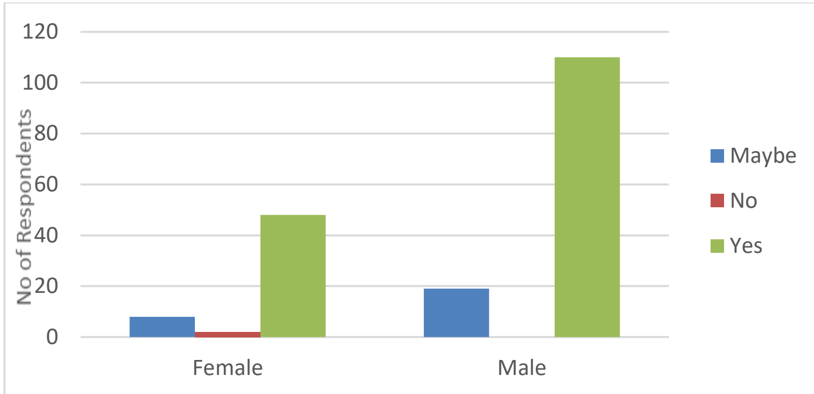

Figure 5: Gender distribution on automation leading to energy conservation

5. **Research Question 5: Is the irregular power supply a contributing factor that leads you to forget to turn off lights and appliances?**

A one-sample T-Test was run to analyze the effect the irregularity of power supply has on respondents forgetting electrical appliances.
Is the irregular power supply a contributing factor that leads you to forget to turn off lights and appliances?
1 = Yes, 2 = No, 3 = Not Sure
Test the responses against μ= 3
α = 0.05

Table 8: One-Sample Test

	Test Value = 3					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Is the irregular power supply a contributing factor that leads you to forget to turn off lights and appliances?	-30.895	186	.000	-1.524	-1.62	-1.43

People who were surveyed had a significantly deviant perception that the irregular power supply is a reason for forgetting to turn off appliances. t (185) = -30.895 p = 0.000
Since p < 0.05 this test is significant. (The sample is significantly different from a μ= 3).
From Figure 5 it can be seen that a total of 117 respondents believe that irregular power supply is largely responsible for causing them to forget appliances even when not needed as against 80 persons who were either unsure or outrightly said no to this.

Figure 6 illustrates a clear position of the respondents, charging irregular power supply as a root cause of wastage by leaving appliances on even when they should not be.

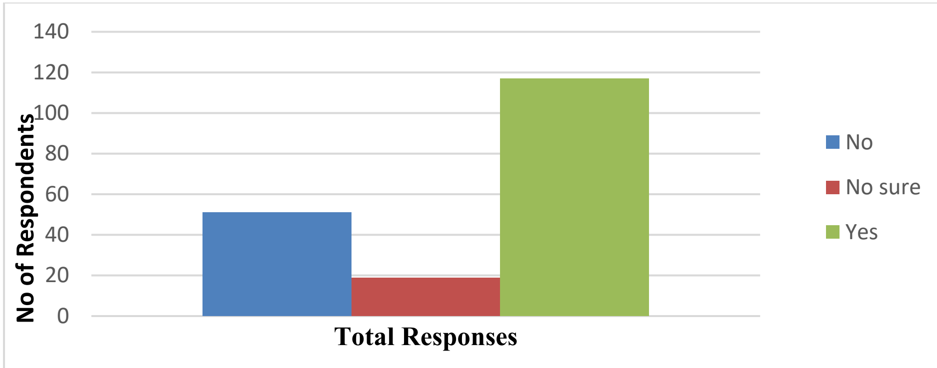

Figure 6: Opinion on whether an irregular power supply was responsible for forgetting appliances.

6. DISCUSSION

The finding of the studies shows a significant difference in the level of awareness based on gender($p<0.004$). This means that based on the sampled respondent about 69.8% of 129 men are not aware of the possibility of using IoT to control power management. Although few women were sampled as compared to the number of men, about 51.7% of the total 58 women considered in the study are aware that IoT can be used for electric power saving. These findings clearly show that there is a need to enlighten Nigerians on how IoT can be used to regulate power wastage most especially in rural areas. It was also found that most of the respondents fall victim to power wastage due to the epileptic power supply among Nigerians. The result is in line with the work of Abdullahi, H. I. (2021)

The finding shows that respondents had a significant deviant perception of sometimes leaving their light on [$t(185)=3.7$ $p=0.00028$]. This result implies that most of the respondents rarely forget to off their security lights. Furthermore, over 40% of the respondent said they sometimes forget to switch off security lights. However, IoT will reduce the chances of forgetting to off the security light. This result is in line with the study of Chidziwisano, G. H., Wyche, S., & Oduor, E. (2020l). however, the work of Chidziwisano et al (2022) said residents of Kenya also forget to turn off their security lights but also wireless routers, and radios.
There was no significant effect of age groups on their acceptability of using the IoT to conserve energy at the $p<.05$ level for the conditions [$F(3,153) = 2.181$, $p = 0.093$]. This implies that all age groups have regard for IoT being used to conserve electricity.

The study also found that there is no significant difference between Male and Female respondents concerning the assumption that the IoT will help conserve energy. That means almost all the respondents agreed that IoT can help conserve energy.

There was a significantly deviant perception that the irregular power supply is a reason for forgetting to turn off appliances [$t(185) = -30.895$ $p = 0.000$]. This result implies that the irregularity in power supply usually is the reason why over 70% of the respondent believe is the reason they forget to turn off their light.

Based on all the findings of this study, the following actions should be considered for the betterment of society and the electric power providers.

1. The electricity power suppliers to take note as well as the Nigerian government to create an avenue for public enlightenment on IoT as a tool for energy conservation.
2. Stakeholders in the construction sector should embrace IoT as a tool to conserve energy by incorporating IoT in their designs and including buildings.
3. People can purchase Plug and play IoT devices that can help in energy conservation and consequently reduce unnecessary electricity bills especially now that the tariff keeps increasing.

6. CONCLUSION

Existing technology and the ability to forge new ideas from existing technology have made the internet of things viable for energy conservation and efficiency, which is applicable in Nigeria. With evidence of poor power generation and distribution, the viability of the internet of things is evident. From the use of the smart grid to aid in the distribution and reduction in the wastage of power supply to the general acceptability of the use of automation to conserve energy. Motion sensors and light detectors have come a long way in providing clients and vendors with options for how to set up smart homes. Such systems will help in the reduction of energy loss and wastage due to forgetting appliances, due to reasons such as the irregularity of power supply. This research and analysis have highlighted the applications of the IoT, its architecture, and its potential for application to conserve energy and reduce energy loss. From the analysis, we can conclude that this is a welcomed technology in Nigeria and would go a long way in assisting electricity consumers in managing energy wastage. This can be achieved through sensors detecting the human presence or time frames set by the user's preference. From opinions obtained and analyzed, positive conclusions have been drawn on the acceptability and possibility of using the internet of things to conserve electricity in Nigeria. Other areas have been highlighted for possible future research. Further

7. RECOMMENDATIONS

Research can be carried out along with research into to electrical consumption of government facilities and mega institutions or bodies. The use of chemical and environmental sensors for use in the area of cooking gas and gaseous security threats and how to curb them could be explored. The idea would be early detection and deployment of countermeasures. With greater awareness and cost-effectiveness, the internet of things for energy conservation in Nigeria will go a long way in saving consumer costs and also aid in the redistribution of power where it is most needed. It will also aid the power generation companies to minimize loss and better detect challenges along distribution lines. This is also buttressed by respondents' positive reviews on the use of the internet of things to conserve energy and as a result, save resources as well. The standards organizations and the architecture of the internet of things mentioned in this research provide insight into what is already available for the design and deployment of such technologies.

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