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Determining key drivers of efficient electricity management practices in public universities in Southwestern Nigeria

An empirical study

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Abstract

Purpose – University campuses are one of the major consumers of electricity. Therefore, it is important to investigate factors related to electricity saving. This study aims to examine the key drivers in achieving efficient electricity management (EEM) practices in public universities.

Design/methodology/approach – To achieve the objective, 23 drivers of EEM practices were identified through a comprehensive literature review and an empirical questionnaire survey was performed with 1,386 electricity end-users of three public universities having staff and students' halls of residences in Nigeria. The collected data were analyzed using the statistical package for social sciences (SPSS version 21) to identify the number of components that could represent the 23 identified drivers.

Findings – The relative importance index ranking results indicated that 18 drivers were critical. The top five most critical drivers were understanding of the issues, understanding the vision and goal of an energy management programme, knowledge and skill, risk identification and good and effective communication among relevant stakeholders. An exploratory factor analysis revealed that the underlying grouped drivers were raising awareness, top management support and robust energy management team, risk management and stakeholders' participation. This study also indicates that the most dominant of the four underlying groups was raising awareness, which highlights the role of increasing awareness and public consciousness as a significant catalyst in promoting EEM practices in public universities.

Research limitations/implications – Geographically, this study is limited to the opinion of respondents in public university campuses in Nigeria. Although this study could form the basis for future studies, its limitation must be considered carefully when interpreting and generalizing the results.

Practical implications – This paper has highlighted a few drivers of EEM practices in public universities. The results of this study present scientific evidence that can be used as a basis for formulating public policies that could be incorporated into the energy management regulations of university buildings. It is most important for policymakers to pay adequate attention to the most critical drivers especially those that are related to the "raising awareness" factor to promote sustainable campuses.

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Originality/value – This study provides practical knowledge for university management to develop effective methods to implement the identified drivers of efficient and sustainable electricity management on the campus. This study also contributes to the body of knowledge in the field of energy management.

Keywords Sustainability, Drivers, Nigerian public universities, Electricity management, Stakeholders participation, Energy management

Paper type Research paper

1. Introduction

Buildings account for up to 40 per cent of global energy consumption (Pout *et al.*, 2002; Asimakopoulos *et al.*, 2012), constituting a huge percentage of energy consumption compared to other sectors of the global economy. The:

> Energy demand from buildings is driven by improved access to energy in developing countries, greater ownership and use of energy-consuming devices, and rapid growth in global buildings floor area, at nearly 3 per cent per year.

If this continues unabated, energy consumption is expected to rise by 50 per cent in the next three decades (IEA, International Energy Agency, 2013, 2019). On the other hand, due to the rise in environmental sensitivity, a few studies have examined the carbon footprint of buildings both in the developed and the developing countries. Carbon dioxide (CO_2) emission is generally considered as the foremost impact index. As fossil fuels are widely used in energy production, building sector-related greenhouse gas (GHG) emissions, such as CO_2, have also been increasing rapidly over the last 100 years. The major portion of present GHG emissions comes from building energy consumption (Santillán-Soto *et al.*, 2019). Buildings contribute as much as one-third of the annual greenhouse gas (GHG) emissions and this figure is projected to increase further (United Nations Environment Programme Sustainable Buildings and Climate Initiative-UNEP-SBCI, 2009; Su and Wang, 2014). In addition, some extant studies have established a great connection between climate change and energy consumption, driven by economic growth and population increase (Hillman and Ramaswami, 2010; Xuchao *et al.*, 2010; Kandananond, 2017).

Environmental problems ensuing from climate change and global warming are becoming increasingly more critical and dangerous. Consequently, the global catastrophic effects of climate change on public health, ecosystems, food and water provision, peace and security of human lives remain indisputable (Byrne *et al.*, 2007). Therefore, there is an urgent need to address these critical issues comprehensively and simultaneously, and this will require major transformative changes in the global building energy system (Van Vuuren *et al.*, 2012). In recent years, the importance of sustainable development of energy systems for policy and decision-makers is receiving continuous recognition anywhere in the world despite the huge sustainability concerns associated with energy-saving (Santoyo-Castelazo and Azapagic, 2014). Also, for both ecological and economic reasons, policies are now being put forward for more sustainable development to reduce greenhouse gas emissions, and thus, combat climate change (Porritt, 2005).

The clamor for the sustainable environment must be widely promoted, integrated and considered in many establishments (Prugh *et al.*, 2000). The profound viewpoint of scientists is that organizations, industries and governments must embrace sustainable practices and embark on mitigation actions to stop additional degradation, to minimize present GHG emissions and to prevent further increases in emissions to reduce these impacts (Stern, 2006). In achieving the goal of a sustainable environment, university campuses represent a sector where large reductions in carbon and other GHG emissions are possible

(Dahle and Neumayer, 2001; von Oelreich, 2004; Moore, 2005; Knuth *et al.*, 2007; Azar and Menassa, 2012).

University buildings have been separately examined in many studies and are classified amongst the buildings presenting the highest energy consumption (Chung and Rhee, 2014). Therefore, to achieve more sustainable development, efforts are now being directed to the university sector for the implementation of many government-related energy reduction measures (Azar and Menassa, 2012). University campuses have been expanding continuously for the past decades and are normally constituted by enormous activities and operations that heavily rely on electricity (Oyedepo, 2012; Fonseca *et al.*, 2018). Almost all aspects of university activities and operations have an imprint of electricity input (Unachukwu, 2010). Electricity is an indispensable force for driving nearly all university activities and operations (Unachukwu *et al.*, 2015). As a result, the electricity consumption of university campuses has also grown, having the highest impact on the national electrical system.

In Nigeria for example, public universities often experience rolling blackouts due to the high demand for electrical energy and the inability of supply authorities to meet their demands (Adelaja *et al.*, 2008). Such losses of electricity supply are hugely disruptive and costly (Maistry and McKay, 2016). To augment the shortage in electricity supply, many Nigerian public universities rely on diesel-powered generators that are expensive and not environmentally friendly. Consequently, high rising electrical energy costs have become a major issue for these public universities. Today, public universities in Nigeria have reached a stage where electricity supply is becoming a major cost factor in almost all their processes and activities (Oyedepo *et al.*, 2015). Unfortunately, this is happening at a time when universities' operating budgets deal with multiple demands but opportunities to increase income are few (Maistry and McKay, 2016).

In recent years, many prominent and highly reputable universities all over the world have now come to terms with the severity of the environmental consequences caused by the excessive energy consumption of their campuses. This realization has made energy management (EM) and reduction strategies a priority objective for energy policies in most universities. Some of the active measures that have been taken to reduce energy consumption in universities include on-campus energy production, retrofitting of built environments, raising awareness about high energy use and the need for efficient energy facilities. Several studies in the relevant research field have also been conducted globally to consider a series of parameters towards seeking the most effective ways of reducing the total energy requirements of university buildings (Nicol and Humphreys, 2002; Masoso and Grobler, 2010). For example, in Ireland, Gallachóir *et al.* (2007) explored simple energy performance indicators and proposed new approaches and tools for assessing the energy performance of university buildings to improve energy policy decision-making and energy management. Also, in Spain, Dominguez *et al.* (2013) developed a power monitoring system to find electrical patterns, detect faults and deviations, predict future power consumption and optimize the peak power of university buildings to enable energy savings. Gul and Patidar (2015) analyzed the relationship between the electrical energy demand profiles and user activities for a university building and found that the operation of an automated energy management system in the case-study building did not show strong sensitivity to the occupancy patterns. The authors concluded that detailed information on the users' behavioural patterns is essential to redesign control strategies for optimum energy performance of university buildings. Yarbrough *et al.* (2015) developed a pivot table analysis tool to investigate the relationship between the maximum energy demand of individual building and the total energy use of all buildings in a university campus by evaluating the pattern of energy use across time and day to understand the factors contributing to energy demand of such building.

Although the consciousness towards energy optimization in public universities has increased substantially over the past decade and approaches to reduce high electricity consumption continue to be developed to move public universities on the path of sustainable development, many universities are still facing the challenge of controlling increasing demand and high electricity bills globally (Oyedepo *et al.*, 2015). Arguably, this is due to certain barriers hampering the advent of sustainable campuses. One of such barriers is the lack of thorough knowledge of the university building stock. In fact, energy demand behaviour in university buildings is the least understood among non-domestic buildings (Gallachóir *et al.*, 2007). In practical terms, energy utilization in university campuses is a very complicated institutional issue on account of the incongruity of activities plus the energy services that take place there (Perez-Lombard *et al.*, 2008; Hawkins *et al.*, 2012; Chung and Rhee, 2014). In other words, this signifies the significance of electricity-consuming items and the role they have been playing, such as in lighting, heating, ventilation and air-conditioning (HVAC), information and communication technologies (ICTs), refrigeration, domestic hot water heating in addition to office equipment and household appliances in both students and staff residences, as well as other intensive use (Nunayon, 2018). Also, it appears that these public universities are barely conscious of effective conservative measures for available limited supply (Abimbola *et al.*, 2015). In addition, despite the high energy demand growth, the university sector has the least amount of energy use data available, which poses significant challenges to benchmarking their energy performance, guiding and strengthening regulatory measures for efficient energy use and informing energy management decisions (Gallachóir *et al.*, 2007). Consequently, plausible challenges that accompany attempts to strike a balance between the heterogeneity of activities and energy services in university buildings include, firstly, energy consumption in a way that would satisfactorily meet the energy needs of users without compromising comfort standards and secondly, reduction in energy consumption through effective and efficient institutional energy management initiatives (Zhang *et al.*, 2011).

To reverse this trend, lasting solutions to assist universities to manage electricity usage efficiently are needed. It is, therefore, important for universities to redefine their core strategies to adapt to real energy needs. Moreover, because universities are saddled with a core obligation to reduce environmental pollution and greenhouse gas emissions considerably, carrying out effective energy management practices is essential in university campuses (Su and Wang, 2014).

Reducing energy use in public universities is impossible without first identifying critical factors that would lead to successful electricity savings, and then initiating more corrective actions through these driving factors (Kim *et al.*, 2019). The focus of this investigation is to identify the key drivers to achieving sustainable and efficient electricity management (EEM) in public universities. This viewpoint is justified because the opportunity to adopt strategic measures to address the success of any EM programme is best exploited in the early stages of an EM programme. Also, this study is important because the majority of the available studies mentioned above concentrated either on one university campus or on general data including the total consumption of the campus. Besides, existing studies focussed on the development and implementation of different energy management methods. Little attention has been paid to the analysis of key drivers of sustainable and efficient electricity savings in universities. A study of this nature is significant for inciting the formulation of energy policies and measures needed to effectively alter the current trends of high electricity use and to promote a positive future for sustainable campuses as it provides the perception of stakeholders in relation to electricity management in university campuses. Also, this study provides information that could aid the university management in making well-informed energy management decisions about university campuses. Finally, identifying and understanding these critical drivers with the aim of increasing the energy efficiency of Nigerian public universities has become a necessity and a viable option for combating climate change in the short term.

The remainder of this paper is organized as follows. The pertinent literature on key drivers of EEM is elaborately discussed in Section 2. Section 3 mainly provides the methodology used to understand the key drivers of EEM from the perspective of public universities. In Sections 4 and 5, the results are presented and extensively discussed, respectively. Concluding remarks summarizing the priority clustered drivers of EEM, which are based on qualities associated with envisioning sustainable university campuses in Nigeria are given in Section 6.

2. Some pertinent literature on drivers of efficient electricity management

In recent years, there is an increasing number of studies about several approaches to managing electricity consumption. However, despite the diverse EM methods, it seems that there are always particular drivers to consider for any EM process to take place successfully. Drivers are those few key areas of activity in which favourable results are absolutely necessary to achieve EM goals. Thollander and Ottosson (2008) considered drivers to be "different types of factors that stress investments in technologies that are both energy-efficient and cost-effective". Cagno and Trianni (2013) attempted to explain drivers of energy efficiency more clearly as "factors facilitating the adoption of both energy-efficient technologies and practices, thus going beyond the view of investments and including the promotion of an energy-efficient culture and awareness".

The strategy for determining key drivers is, nevertheless, a procedure that attempts to make the key areas that are essential for the achievement of a successful EM more obvious. Previous studies have addressed various factors that drive the implementation of EEM practices. For example, Capehart *et al.* (2006) and Kim *et al.* (2019) pointed out that top management commitment and training are important ingredients for the successful implementation and operation of an EM programme. Commitment from the top management must be strong and highly visible, without which the programme will likely fail to reach its objectives. As EM is a unique undertaking, training and retraining at all levels are vital.

Also, Saleh *et al.* (2015) made an important contribution, categorizing the drivers into different types such as operation and risk management, leadership management, partnerships and resources and awareness management. To the best of the authors' knowledge, this was the first study that classified drivers of efficient energy from extant literature into distinct groups.

Many other drivers directly related to successful EM operations include the development and implementation of energy policies and reforms (Choong *et al.*, 2012; Brunke *et al.*, 2014); performing energy audit (Haji-Sapar and Lee, 2005; Kong *et al.*, 2013); creating and increasing general energy awareness (De Groot *et al.*, 2001; Reddy, 2013); improvement of facility energy awareness (Affisco, 2012); provision of energy information (Matsukawa, 2004; Abrahamse *et al.*, 2005; Maistry and Annegarn, 2016).

In addition, it has been strongly advocated that education by research and development, teaching and learning is an important driver for the advancement of innovative solutions in terms of energy-efficient consumption and emission reduction, going beyond the construction of alternatives for the future sustainable campuses (Castleberry *et al.*, 2016; May *et al.*, 2017).

Taking inspiration from project management and sustainable development-related studies, the current authors also found some drivers vital and their inclusion necessary for consideration to trigger successful EM in universities. Among other factors, leadership was identified by Xu *et al.* (2011); understanding the issues by Khang and Moe (2008); increase motivation by giving incentives in the form of awards by Yang (2013); risk identification and risk evaluation by Kwak and Stoddard (2004); development of a response to the risk and development of preventive measures for the risk by Teller and Kock (2013); community participation and collaboration by Ferreira *et al.* (2006), Lozano (2006); and Velazquez *et al.* (2006).

Operations and maintenance (Cooke-Davies, 2002); monitoring, review and verification (Boie and Kannan, 2003; Zilahy, 2004; Brundage *et al.*, 2016); commitment to continuous improvement (Bessant *et al.*, 2001; Cheng and Li, 2002; Wu and Chen, 2006); understanding the vision and goal of an EM programme (Baccarini and Collins, 2003); good and effective communication among relevant stakeholders (Chan *et al.*, 2001); knowledge and skill (Belassi and Tukel, 1996; Castleberry *et al.*, 2016); trust among stakeholders (Sanvido *et al.*, 1992) are all regarded as key drivers for the success of any sustainable and efficient EM programme. Financial-related drivers (Thollander *et al.*, 2013) such as apportionment of adequate resources are also thought to be important.

By reviewing the literature, it is evident that the most relevant drivers differ from various perspectives. From a holistic view, the drivers of EEM, based on the above literature review, have been distilled into 23 key drivers, as shown in Table I. These factors are well-documented in previous research and more applicable. Thus, the identification of this set of drivers largely focussed on factors that have received considerable attention in previous studies conducted in different countries.

The literature review above summarizes past studies related to the drivers for applying EEM practices. These studies tend to primarily focus on analyzing industry-specific drivers, which may limit their application to EEM implementation in higher education institutions. In addition, several of these studies mainly focussed on developed countries and regions and did not address the issues detailed above for developing countries. As a result, this present study aims to systematically examine the major drivers for implementing EEM on campuses, as seen from the perspective of Nigerian public universities, thereby helping all stakeholders to adopt optimal strategies in the successful delivery of EEM in developing countries.

3. Methodology

3.1 Research approach and instrument adopted for the study

The whole approach to the design process of conducting research involves theoretical phases that underpin the collection and analysis of data (Dainty, 2007; Creswell, 2009; Badu *et al.*, 2012). In this study, the authors adopted an inductive approach. Also, from the scientific point of view, broadly, quantitative and qualitative research approaches are obtainable (Bryman and Bell, 2015). This study adopted a quantitative approach. It is objective, scientific in nature, and entails the generation of data in a quantitative form that can be subjected to rigorous quantitative analysis using standard statistical techniques in a formal and rigid fashion (Naoum, 2007). This implies that the aim of the study must be well-defined before the researcher commences the study (Neill, 2007). The quantitative approach embraces subjective opinions (of respondents) to study relationships between facts (Naoum, 2007; De Vaus, 2002; Fellows and Liu, 2008).

Table I. Key drivers of EEM practices

Code	Drivers	References
KDR01	Development and implementation of energy policies and reforms	Pinto and Slevin (1987, 1988, 1989), Pinto and Prescott (1988), Sanvido *et al.* (1992), Cooke-Davies (2002), Lozano (2006), Velazquez *et al.* (2006), Xu *et al.* (2011), Choong *et al.* (2012), Yang (2013), Brunke *et al.* (2014)
KDR02	Leadership	Pinto and Slevin (1987, 1988; 1989), Pinto and Prescott (1988), Sanvido *et al.* (1992), Belassi and Tukel (1996), Salaheldin (2009), Xu *et al.* (2011), Choong *et al.* (2012)
KDR03	Increase motivation by giving incentives in the form of awards	Morris and Hough (1987), Pinto and Slevin (1987, 1988; 1989), Pinto and Prescott (1988), Yang (2013)
KDR04	Performing energy audits	Pinto and Slevin (1989), Belassi and Tukel (1996), Cooke-Davies (2002), Haji-Sapar and Lee (2005), Velazquez *et al.* (2006), Choong *et al.* (2012), Kong *et al.* (2013)
KDR05	Monitoring, review and verification	Morris and Hough (1987), Ajanlekoko (2001), Cooke-Davies (2002), Hyvari (2006), Lozano (2006), Muller and Turner (2007), Olotuah and Bobadoye (2009), Ibem and Amole (2011), Jiboye (2011), Oyebanji *et al.* (2011), Xu *et al.* (2011), Aluko (2012), Choong *et al.* (2012), Yang (2013)
KDR06	Apportionment of adequate resources	Pinto and Slevin (1987, 1988; 1989), Pinto and Prescott (1988), Belassi and Tukel (1996), Ajanlekoko (2001), Cheng and Li (2002), Cooke-Davies (2002), Baccarini and Collins (2003), Hyvari (2006), Khang and Moe (2008), Olotuah and Bobadoye (2009), Ibem and Amole (2011), Jiboye (2011), Oyebanji *et al.* (2011), Aluko (2012), Yang (2013)
KDR07	Training provisions	Schultz *et al.* (1987), Pinto and Slevin (1987, 1988; 1989), Pinto and Prescott (1988), Pinto and Kharbanda (1995), Capehart *et al.* (2006), Salaheldin (2009), Choong *et al.* (2012), Yang (2013)
KDR08	Operations and maintenance	Morris and Hough (1987), Pinto and Slevin (1989), Belassi and Tukel (1996), Cooke-Davies (2002), Choong *et al.* (2012)
KDR09	Commitment to continuous improvement	Pinto and Kharbanda (1995), Belassi and Tukel (1996), Bessant *et al.* (2001), Cheng and Li (2002), Cooke-Davies (2002), Velazquez *et al.* (2006), Wu and Chen (2006), Salaheldin (2009), Choong *et al.* (2012)
KDR10	Understanding the vision and goal of an EM programme	Hughes (1986), Morris and Hough (1987), Schultz *et al.* (1987), Pinto and Slevin (1987, 1988; 1989), Pinto and Prescott (1988), Belassi and Tukel (1996), Ajanlekoko (2001), Cooke-Davies (2002), Baccarini and Collins (2003), Andersen and Jessen (2006), Hyvari (2006), Lozano (2006), Olotuah and Bobadoye (2009), Jiboye (2011), Oyebanji *et al.* (2011)
KDR11	Good and effective communication among relevant stakeholders	Pinto and Slevin (1987, 1988, 1989), Pinto and Prescott (1988), Belassi and Tukel (1996), Ajanlekoko (2001), Chan *et al.* (2001), Cheng and Li (2002), Andersen and Jessen (2006), Hyvari (2006), Lozano (2006), Olotuah and Bobadoye (2009), Ibem and Amole (2011), Jiboye (2011), Choong *et al.* (2012)
KDR12	Knowledge and skill	Morris and Hough (1987), Pinto and Slevin (1989), Belassi and Tukel (1996), Xu *et al.* (2011), Yang (2013), Castleberry *et al.* (2016)
KDR13	Trust among stakeholders	Pinto and Slevin (1989), Sanvido *et al.* (1992), Belassi and Tukel (1996), Lozano (2006), Xu *et al.* (2011)
KDR14	Risk identification	Morris and Hough (1987), Pinto and Slevin (1987, 1988, 1989), Pinto and Prescott (1988), Belassi and Tukel (1996), Ajanlekoko (2001), Chan *et al.* (2002), Cooke-Davies (2002), Baccarini and Collins (2003), Kwak and Stoddard (2004), Xu *et al.* (2011), Teller and Kock (2013)
KDR15	Risk evaluation	Morris and Hough (1987), Pinto and Slevin (1987, 1989), Belassi and Tukel (1996), Ajanlekoko (2001), Chan *et al.* (2002), Cooke-Davies (2002), Baccarini and Collins (2003), Xu *et al.* (2011)

(*continued*)

Table I.

Code	Drivers	References
KDR16	Development of a response to the risk	Pinto and Slevin (1987, 1988, 1989), Pinto and Prescott (1988), Belassi and Tukel (1996), Ajanlekoko (2001), Chan *et al.* (2002), Cooke-Davies (2002), Baccarini and Collins (2003), Teller and Kock (2013)
KDR17	Development of preventive measures for the risk	Pinto and Slevin (1987, 1988, 1989), Pinto and Prescott (1988), Belassi and Tukel (1996), Ajanlekoko (2001), Chan *et al.* (2002), Cooke-Davies (2002), Baccarini and Collins (2003)
KDR18	Understanding the issues	Pinto and Slevin (1987, 1988, 1989), Pinto and Prescott (1988), Belassi and Tukel (1996), Baccarini and Collins (2003), Andersen and Jessen (2006), Khang and Moe (2008), Choong *et al.* (2012)
KDR19	Creating and increasing general energy awareness	Pinto and Slevin (1987, 1988, 1989), Pinto and Prescott (1988), Belassi and Tukel (1996), De Groot *et al.* (2001), Lozano (2006), Choong *et al.* (2012), Reddy (2013), Yang (2013)
KDR20	Improvement of facility energy awareness	Affisco, (2012), Choong *et al.* (2012), Yang (2013)
KDR21	Education by research and development, teaching and learning	Lozano (2006), Velazquez *et al.* (2006), Choong *et al.* (2012), Yang (2013), Castleberry *et al.* (2016)
KDR22	Community participation and collaboration	Ferreira *et al.* (2006), Lozano (2006), Velazquez *et al.* (2006)
KDR23	Provision of energy information	Midden *et al.* (1983), Gow and Morse (1988), Pinto and Slevin (1987, 1988; 1989), Pinto and Prescott (1988), Belassi and Tukel (1996), Ajanlekoko (2001), Matsukawa (2004), Abrahamse *et al.* (2005), Andersen and Jessen (2006), Hyvari (2006), Lozano (2006), Olotuah and Bobadoye (2009), Ibem and Amole (2011), Jiboye (2011), Yang (2013), Maistry and Annegarn (2016)

Three public universities having staff and students' halls of residences were purposively selected. In this regard, Obafemi Awolowo University (OAU) situated on about 5,000 acres (20.2 km^2) of a total of 13,000 acres (52.6 km^2) university-owned land in Ile-Ife, Osun State (Latitude 7° 31′ 6″ N and Longitude 4° 31′ 22″ E); The Federal University of Technology, Akure (FUTA) situated on 1581 acres of land (6.4 km^2) in Akure, Ondo State (Latitude 7° 17′ 25″ and Longitude 5° 9′ 19″); and University of Ibadan (UI) situated on over 2,550 acres (10.3 km^2) of land in Ibadan, Oyo State (7° 26′ 30″ N, 3° 54′ 0″ E); all in Nigeria were selected. In addition, the three universities are coeducational higher education institutions. Four important criteria were considered for selecting these universities:

- the frequency of electricity supply;
- the availability of hostels for undergraduate students, both male and female;
- the availability of student hostels for postgraduate students, both male and female; and
- the availability of staff residence.

Furthermore, the total study population identified in the study areas was 38,103 electricity users: 15,883 in OAU, 6,707 in FUTA and 15,513 in UI. The population of this study was stratified into electricity users in staff offices, commercial centres, staff and student residences with a percentage electricity consumption distribution of 28.66 per cent, 9.61 per cent, 21.48 per cent and 40.25 per cent in OAU; 40.81 per cent, 6.70 per cent, 15.79 per cent and 30.70 per cent in FUTA; and 17.39 per cent, 3.52 per cent, 8.59 per cent and 70.50 per cent in UI, respectively (information on the actual consumption – in kWh – was not provided by the universities). Student halls were categorized into two, namely, undergraduate – male and female and postgraduate – male and female hostels. Student hostels were purposively selected to capture variation in gender and levels of study. In OAU, FUTA and UI, Moremi, Jadesola Akande and Awolowo halls, respectively were selected as representatives of undergraduate female hostels in the universities, while Awolowo, Peter Adeniyi and Independence halls were selected as undergraduate male hostels in OAU, FUTA and UI, respectively. Murtala Muhammed Postgraduate hall in OAU, FUTA Postgraduate hall in FUTA and Abdusalam Abubakar Postgraduate hall in UI for both Male and Female students were also sampled. To determine the sample size, one out of every twenty (5 per cent) students were selected in each hall, one out of every twenty (5 per cent) households and shops were selected while accidental sampling was used for the selection of staff members (both academic and non-academic).

Basically, the authors adopted a structured close-ended questionnaire survey targeted to elicit data from stakeholders in Nigerian public universities. Existing similar studies such as De Groot *et al.* (2001), Rohdin *et al.* (2007), Shi *et al.* (2013), Brunke *et al.* (2014) also used questionnaire surveys. For example, based on a questionnaire survey among Dutch firms, De Groot *et al.* (2001) identified the factors that determine the investment behaviour of firms, their attitude towards various types of energy policy, and their responsiveness to changes in environmental policy in The Netherlands. Rohdin *et al.* (2007) investigated the existence of different barriers to and driving factors for the implementation of energy efficiency measures in the energy-intensive Swedish foundry industry. Brunke *et al.* (2014) empirically investigated the barriers and drivers to the adoption of energy conservation measures, energy management practices and energy services in the Swedish iron and steel industry. While all of these studies were conducted in industries, similarities can be found with the current study in that identifying key drivers of EM was a subject for investigation. The need for generalization in the findings across Nigerian public universities influenced the choice of a questionnaire survey. A questionnaire survey enhances the consistency of observations and improves replication due to its inherent standardized measurement and sampling techniques (Oppenheim, 2003).

An ordinal Likert-type scale of 1 to 5 was used for the questionnaire design. The five-point Likert rating scale is commonly used to measure attitudes and requires that respondents should choose options that best reflect their attitude or opinion about every question statement (Naoum, 1998; De Groot *et al.*, 2001; Enshassi *et al.*, 2009; Holt, 2014). Some studies have also adopted both a Likert scale below and above the five points (United Nations Environment Programme, UNEP, 2006; Rohdin *et al.*, 2007; Bond and Perrett, 2012). However, the Likert scale is best when it is fewer than seven points (Lee, 2006) but becomes significantly less accurate if it is below five or above seven scale points (Johns, 2010). The five-point Likert scale has become widely accepted because it is easier for respondents to clearly manage their choice of points.

The questionnaire was divided into two sections. The first part enquired information on the demographic characteristics of the respondents and contained items such as age, gender, status, and duration of stay on campus. The second part enquired information on applicants' insights of key drivers of sustainable and EEM practice in the study area. In investigating key drivers, the various key drivers identified in the literature (Table I) were presented in the questionnaire. The respondents were invited to rate the degree of significance of the listed drivers to the achievement of EEM in Nigerian public universities by using a five-point Likert scale of one (*not significant*) to five (*extremely significant*).

A total of 1,386 questionnaires were distributed randomly to stakeholders within the university campuses. A total of 1,250 questionnaires were completed and returned but only

1,182 stakeholders responded positively to the survey and all their responses were found valid and suitable for use in the analysis. This represents a response rate of 85.28 per cent, which was well over the acceptable 30 per cent response rate opined by Moser and Kalton (1999), Akintoye (2000), Enshassi *et al.* (2006), Enshassi *et al.* (2007) and Hwang *et al.* (2015). It is also higher than those considered in previous studies (De Groot *et al.*, 2001; Rohdin *et al.*, 2007; Enshassi *et al.*, 2013).

To ensure that reliable results are obtained, a reliability test (Cronbach's alpha - α) of the research instrument was conducted (Kothari, 2004). For the instrument to be reliable, the value of Cronbach's alpha must be greater than 0.65 (Kumar, 2011). Because the Cronbach's α value of 0.917 was obtained, the questionnaire used possessed high reliability and internal consistency (Moser and Kalton, 1999; George and Mallery, 2003; Pallant, 2005).

3.2 Methods of data analysis

Non-parametric statistics involving descriptive statistics analysis, relative importance index analysis and factor analysis were adopted. Descriptive statistics such as percentage was used in analyzing data related to the demographic characteristics of respondents in quantitative terms. The graphical technique used for presenting the results from the descriptive analysis was the pie chart. The relative importance index analysis was conducted to provide a degree of importance for each EEM driver while inferential statistics such as factor analysis was used to identify and classify/group drivers that can significantly enhance sustainable and EEM practice in university campuses. The Statistical Package for the Social Sciences (SPSS version 20) and Microsoft Excel were used for all these analyses. More details on the various analyses can be referred to in Sections 4.2, 4.3 and 4.4.

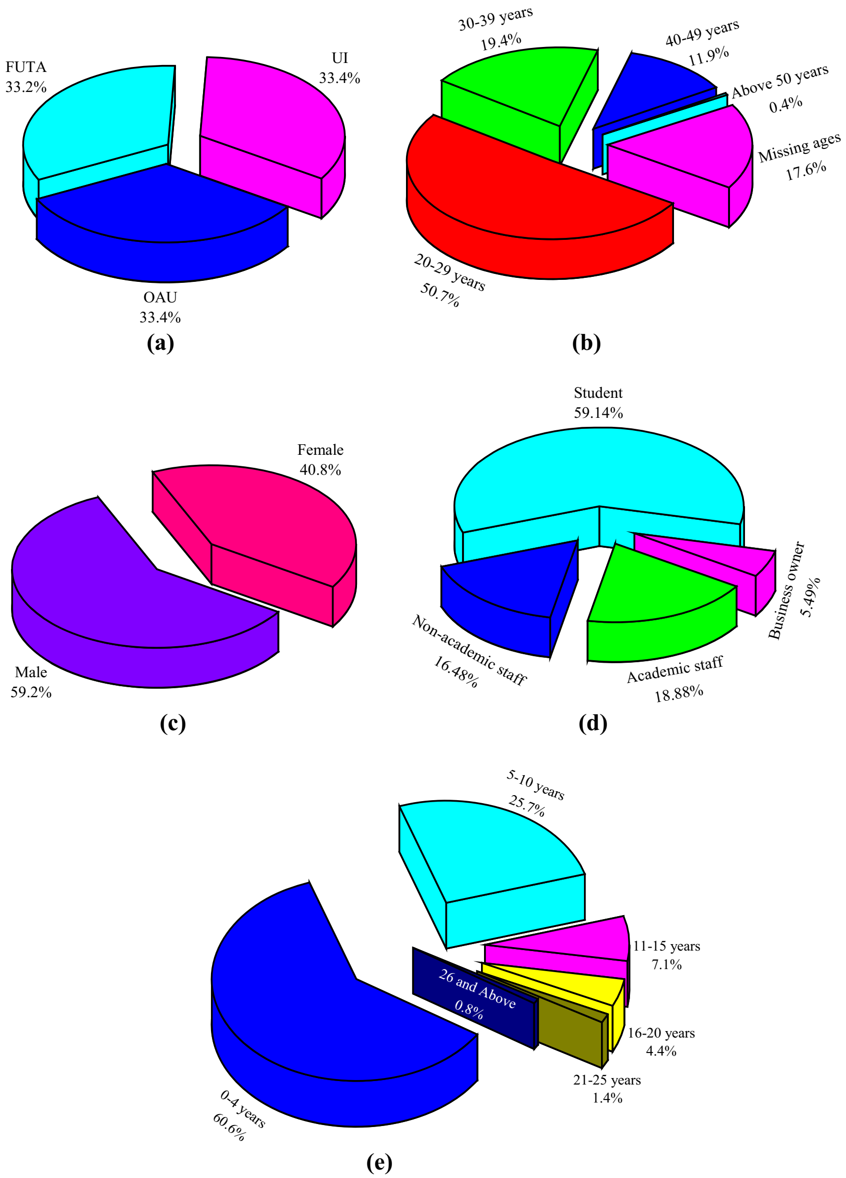
4. Results

4.1 Respondents' general information

Figure 1 presents the results of the demographic characteristics of university stakeholders on key factors for EEM practices in the study area. Of the 1,182 responses, 33.4 per cent were from OAU, 33.4 per cent from UI and 33.2 per cent from FUTA [Figure 1(a)]. The results showed that 50.7 per cent of the respondents were within the age band of 20-29 years, 19.4 per cent between 30-39 years, 11.9 per cent between 40-49 years, and only 0.4 per cent were above 50 years while 17.6 per cent, which did not indicate their age band were regarded as missing ages [Figure 1(b)]. More than half (i.e. 59.2 per cent) were males and 40.8 per cent were females [Figure 1(c)]; 59.1 per cent students, 18.9 per cent academic staff, 16.5 per cent non-academic staff and 5.5 per cent business owners completed the survey [Figure 1(d)]. This signifies that the major users of electricity in university buildings were students, whereas the business owners in university campuses represent a minor proportion. Also, the majority (60.6 per cent) of respondents fell within 0-4 year band of residence on campus, one-quarter (25.7 per cent) between 5 and 10 years, 7.1 per cent between 11 and 15 years, 4.4 per cent between 16 and 20 years, 1.4 per cent between 21 and 25 years and only very few respondents (0.8 per cent) had stayed on campus for 26 years and above [Figure 1(e)]. This distribution indicating the duration of residence on campus is understandable as most of the respondents were students whose study duration was between 4 and 5 years.

4.2 Relative importance index analysis for drivers of efficient electricity management

The degree of influence of each driver on EEM practices was evaluated using the relative importance index technique. The approach has been widely used in various survey studies (Chinyio *et al.*, 1998; Braimah and Ndekugri, 2009) and is considered in this study as an excellent technique for aggregating the scores of the respondent-rated drivers on an ordinal



Notes: (a) Proportion of respondents in each university; (b) age distribution of respondents; (c) gender distribution of respondents; (d) status of respondents; (e) number of years stayed on Campus

Figure 1.
General information of respondents

scale. The drivers were first measured against a scale to determine the significance of the rated drivers, which were then inserted into equation (1) to transform this scale into the corresponding relative importance index (RII) of the drivers. Finally, the drivers were ranked according to their influences based on the values of the computed relative importance index.

$$RII = \frac{\sum_{i=1}^{5} W}{A \times N} \tag{1}$$

where RII indicates the relative importance index of each driver, W represents the weighting assigned to the drivers by each respondent on a scale of one to five, with one representing the lowest and five the maximum. A signifies the maximum weight, that is, 5 in this study, and N connotes the total number of responses in the sample.

The results of a complete list of RII and ranking, as well as the key descriptive values of drivers, are shown in Table II. The standard deviations (S.D.) of the drivers are generally less than 1 (0.846-1.127) indicating a paltry difference in responses regarding the influence of listed drivers. The estimated RII values ranged from 0.530 to 0.660 indicating that while some drivers, not unexpectedly, have a very strong influence on EEM practices, others do not. If two or more drivers had the same RII rating, the highest rank was given to the driver with the lowest S.D. According to Akadiri *et al.* (2013), five essential thresholds that can be transformed from the RII values include High (H) for $0.8 \leq \text{RII} \leq 1$, High–Medium (H–M) for $0.6 \leq \text{RII} < 0.8$, Medium (M) for $0.4 \leq \text{RII} < 0.6$, Medium–Low (M–L) for $0.2 \leq \text{RII} < 0.4$, and Low (L) for $0 \leq \text{RII} < 0.2$. Using a cut-off value of 0.4 – only those drivers with RII values greater than or equal to 0.4 were defined as relevant – the results showed that the EEM drivers could be grouped into two categories (Figure 2). Firstly, the drivers with a "High–Medium" level of significance, with RII values lying between 0.6 to 0.8. Secondly, the drivers with the "Medium" level of significance, with RII values lying between 0.4 and 0.6.

Based on the ranking results in Table II, a total of 18 drivers were highlighted to have a "High-Medium" level of significance in achieving EEM. Some drivers within the "High–Medium" level of significance, nevertheless, were ranked relatively higher. Five out of ten highest-ranking drivers are awareness-related, three are related to inclusive participation of stakeholders, one is risk-related while the remaining one is policy-related. For example, a comprehensive understanding of the issues, which is awareness-related was perceived as the most relevant driver of EEM among all drivers with a RII value of 0.660 (i.e. ranked 1st). This is different from studies in other sectors such as industrial, in which financially and organizationally related drivers were the highest ranked (Thollander *et al.*, 2013). The stakeholders' responses illustrated that there is a considerable need for an explicit programme aimed at raising awareness on campus energy situations, opportunities to reduce electricity use and stimulating the spread of best practices for energy efficiency improvement in the education sector.

"Understanding the vision and goal of EM programme" and "knowledge and skill" are relatively high at RII values of 0.645 and 0.641 ranking 2nd and 3rd most important drivers, respectively. "Risk identification" having a RII value of 0.638 was also perceived to be a strong driving force to the adoption of EEM practices and ranked fourth. Other drivers rated high in importance in the order of ranking were "good and effective communication among relevant stakeholders", "improvement of facility energy awareness", "education by research and development (R&D), teaching and learning", "commitment to continuous improvement", "creating and increasing general energy awareness" and "development and implementation of energy policy and reforms, with RII values of 0.637, 0.633, 0.632, 0.631,

Codes	Drivers Description	RII[a]	SD[b]	Overall ranking	Significance level
KDR18	Understanding the issues	0.660	0.846	1	H–M
KDR10	Understanding the vision and goal of EM programme	0.645	0.898	2	H–M
KDR12	Knowledge and skill	0.641	0.918	3	H–M
KDR14	Risk identification	0.638	0.886	4	H–M
KDR11	Good and effective communication among relevant stakeholders	0.637	0.894	5	H–M
KDR20	Improvement of facility energy awareness	0.633	0.893	6	H–M
KDR21	Education by research and development (R&D), teaching and learning	0.632	0.925	7	H–M
KDR09	Commitment to continuous improvement	0.631	0.952	8	H–M
KDR19	Creating and increasing general energy awareness	0.630	0.869	9	H–M
KDR01	Development and implementation of energy policy and reforms	0.628	0.929	10	H–M
KDR16	Development of a response to the risk	0.626	0.915	11	H–M
KDR08	Operations and maintenance	0.625	0.869	12	H–M
KDR15	Risk evaluation	0.624	0.919	13	H–M
KDR17	Development of preventive measures for the risk	0.618	0.980	14	H–M
KDR13	Trust among stakeholders	0.614	1.024	15	H–M
KDR22	Community participation and collaboration	0.612	0.992	16	H–M
KDR23	Provision of energy information	0.611	1.033	17	H–M
KDR02	Leadership	0.601	0.995	18	H–M
KDR06	Apportionment of adequate resources	0.599	1.008	19	M
KDR07	Training provisions	0.599	1.104	20	M
KDR04	Performing energy audit	0.597	0.952	21	M
KDR05	Review and verification	0.595	1.008	22	M
KDR03	Increase motivation by giving incentives in the form of awards	0.530	1.127	23	M

Notes: [a]Relative importance index; [b]Standard deviation

Table II.
Relative importance index for drivers of EEM practices

0.630, and 0.628; ranked 5th, 6th, 7th, 8th, 9th and 10th, important drivers of EEM, respectively. The remaining "High-Medium" significance level drivers were "development of a response to the risk" (RII = 0.626), "operations and maintenance" (RII = 0.625), "risk evaluation" (RII = 0.624), "development of preventive measures for the risk" (RII = 0.618), "trust among stakeholders" (RII = 0.614), "community participation and collaboration" (RII = 0.612), "provision of energy information" (RII = 0.611), "leadership" (RII = 0.601) ranking 11th, 12th, 13th, 14th, 15th, 16th, 17th and 18th, respectively.

Also, as mentioned earlier, some of the drivers were recorded to have a "Medium" level of significance including "apportionment of adequate resources" (RII = 0.599), "training provisions" (RH = 0.599), "performing energy audit" (RII = 0.597), "review and verification" (RII = 0.595) and "increase motivation by giving incentives in the form of awards" (RII = 0.530), which ranked 19th, 20th, 21st, 22nd and 23rd, respectively. In the lowest position, the authors found the driver "increase motivation by giving incentives in the form of awards" (RII = 0.530). Despite being ranked the least among the 23 drivers, the respondents still recognized the importance of increasing motivation, at the same time, acknowledged that awards are powerful incentives that can motivate and enhance stakeholders' responsiveness

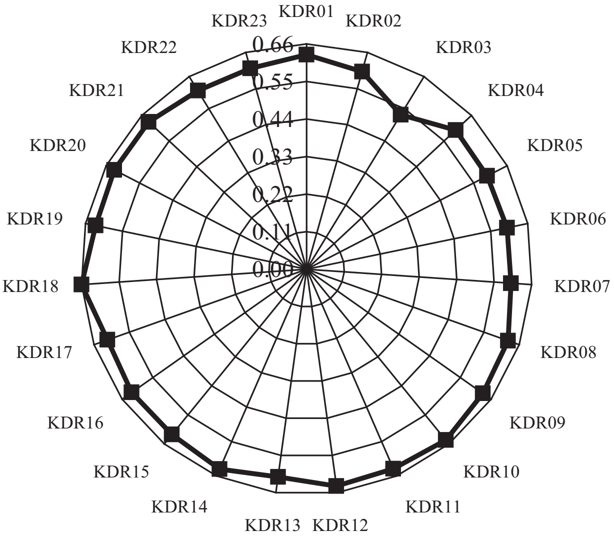


Figure 2.
Relative importance index of the EEM drivers

for better participation in EM. This implies that the drivers with low RII did not mean that they were not at all important for achieving EEM, but rather the respondents only highlighted the relative importance of drivers from their standpoint. Finally, from the results in Table II, an interesting observation is that none of the drivers fell under the two least levels of significance – "Medium-Low" and "Low". Again, this clearly reinforces how important the drivers were to stakeholders in achieving EEM on university campuses.

4.3 Factor analysis for drivers of efficient electricity management

In total, 23 key drivers for the implementation of EEM practices in public universities in Southwestern Nigeria were subjected to factor analysis. Largely, there exists the likelihood that these drivers could be measuring some common aspects of the underlying dimension known as *factors* or *latent variables*. Although the most significant drivers were identified using ranking analysis in Section 4.2, the essence of performing a factor analysis was to identify and establish similar underlying effects that could easily explain the pattern of correlations within a set of observed drivers. Typically, this approach can reduce the data set from a group of interrelated drivers to a more manageable and concise size (or *smaller set*) of significant drivers (while retaining as much of the original information as possible) that explain most of the variance that is observed in a much larger number of manifest drivers.

In this study, a principal component analysis (PCA) was conducted on the 23 key drivers with varimax rotation. However, the reliability and suitability of the dataset for factor analysis depend on several conditions. One of such is the sample size. Divergent views have been shared about the necessary sample size for factor analysis. Sapnas and Zeller (2002) and De Winter *et al.* (2009) suggested that the sample size should be larger than 50. In 2010, Hair, Anderson, Babin and Black endorsed that it is comforting to have a sample size of 100 and above. Tabachnick and Fidell (2007) agreed that it is appropriate to have not less than 300 samples for factor analysis to be considered. Supportive of the above-mentioned notions, Pallant (2005) recommended the use of a larger size of samples. Indeed, 100 has been rated as a poor sample size, 300 as good and 1,000 as excellent (Comrey and Lee, 1992). The sample size for the current study was 1,182, which was well above the range suggested, and can be considered adequate for factor analysis based on the submissions of these earlier studies.

Another critical issue to consider when adopting factor analysis is the number of drivers. Hair *et al.* (1998) approved that between 20-50 drivers are adequate for factor analysis, stating that beyond this range, the extraction of common drivers becomes inaccurate. Other studies demonstrated that when the sample size is large enough, a smaller number of drivers could be used (Ahadzie *et al.*, 2008; Kim *et al.*, 2016). In addition, many authors recommended that having between 5 to 10 times as many respondents as the number of drivers is adequate (Nunnally, 1978; Kass and Tinsley, 1979; Tabachnick and Fidell, 2007; Hair *et al.*, 2010). Furthermore, MacCallum *et al.* (1999) stated that reasonable solutions could still be obtained even if the respondents to drivers' ratio is less than 5 or smaller than is conventionally believed to be suitable for a concrete factor analysis. This opinion has been proven to be true in Shen and Liu (2003), Koskal and Arditi (2004) and Li *et al.* (2005) with a ratio of 1.59, 2.48 and 3.39, respectively. In this study, the factor analysis contained a total of 1,182 respondents and 23 drivers. This implied that the analysis had 1,182/23 = 51 respondents per driver, which was also well above the specification. It suffices, therefore, to conclude that the sample size was adequate in association with the number of drivers.

Also, Malhotra and Birks (2006) submitted that the Kaiser–Meyer–Olkin (KMO) and Bartlett's test of sphericity can be used to determine the suitability of sampling for factor analysis. While the KMO is a common measure used in testing the consistency of drivers and whether the partial correlations among them are small (Sharma, 1996), Bartlett's test of sphericity shows whether the correlation matrix resembles an identity matrix (Field, 2005). Usually, when Bartlett's test of sphericity is significant ($p < 0.05$), and the value of the KMO index is > 0.5, the data set is considered appropriate for factor analysis (Pallant, 2005; Mane and Nagesha, 2014). Specifically, Tabachnick and Fidell (2007) had recommended that the minimum KMO index appropriate for factor analysis should be 0.6. The KMO statistic varies between 0 and 1 (Field, 2005). The results indicate that all requirements for the application of factor analysis were fulfilled having obtained a KMO value of 0.935 ('superb' according to Field, 2005). In the current case, as the KMO value was close to 1, the patterns of correlations were relatively compact and so, factor analysis would yield distinct and reliable factors (Field, 2005). The Bartlett's test of sphericity also showed statistical significance (chi-square = 14,964.155; $p = 0.000$).

The data have been found to meet all the necessary requirements. Therefore, through the application of a PCA on the 23 key drivers with orthogonal rotation (varimax), the authors could then straightforwardly conduct the factor analysis for the 23 key drivers of EEM practices in public universities in Southwestern Nigeria. The rotation maintains the cumulative percentage of variation explained by the extracted components, but that variation is now spread more evenly over the components. To be considered necessary for practical significance, Meyers *et al.* (2006) opined that the cumulative percentage variance explained by an acceptable solution must not be less than 50 per cent. Preferably, Malhotra and Birks (2006) posited that it should be higher than 60 per cent.

Table III shows that four components having eigenvalues greater than 1.0 were extracted with the variance explained by each component presented. Component 1 contributed 20.34 per cent, Component 2 contributed 18.02 per cent, Component 3 contributed 14.73 per cent and Component 4 contributed 11.83 per cent. Altogether, the four components explain nearly 65 per cent of the variability in the original 23 key drivers to enable a considerable reduction of the complexity of the data set by using these components, with only a 35 per cent loss of information.

Table III.
Total variance explained on the drivers of EEM practices

Component	Initial eigenvalues Total	% of variance	Cumulative % of variance explained	Extraction sums of squared loadings Total	% of variance	Cumulative % of variance explained	Rotation sums of squared loadings Total	% of variance	Cumulative % of variance explained
1	10.277	44.683	44.683	10.277	44.683	44.683	4.679	20.344	20.344
2	2.094	9.103	53.786	2.094	9.103	53.786	4.145	18.024	38.367
3	1.470	6.391	60.177	1.470	6.391	60.177	3.387	14.726	53.093
4	1.092	4.747	64.924	1.092	4.747	64.924	2.721	11.831	64.924
5	0.977	4.249	69.173						
6	0.810	3.521	72.694						
7	0.773	3.359	76.053						
8	0.629	2.733	78.786						
9	0.524	2.278	81.064						
10	0.448	1.949	83.013						
11	0.431	1.873	84.886						
12	0.420	1.827	86.714						
13	0.409	1.777	88.490						
14	0.346	1.505	89.995						
15	0.325	1.412	91.407						
16	0.314	1.365	92.772						
17	0.283	1.230	94.001						
18	0.270	1.173	95.175						
19	0.260	1.132	96.307						
20	0.244	1.061	97.368						
21	0.227	0.986	98.354						
22	0.215	0.935	99.289						
23	0.163	0.711	100.000						

The most feasible way to verify the results of the factor analysis is the scree plot. The scree plot simply displays the eigenvalues for each of the key drivers, usually from the first eigenvalue (the one that explains the most variance) to the last eigenvalue (Malhotra and Birks, 2006). It is important to critically examine the scree plot together with the component matrix to determine the factors to retain (Pallant, 2005).

On the screen plot in Figure 3, the slope flattens out as the amount of variance that is explained by each eigenvalue gradually decreases. The graph was thoroughly examined to establish the breakpoint where the curve levels off. As illustrated in Figure 3, the number of factors to be extracted was equivalent to the number of data points above the line of the breakpoint. The data points falling directly on the broken line were not counted. A few possible and complex occasions in which the data points would be bunched together and become indistinguishable (De Vaus, 2002; Malhotra and Birks, 2006; Hair *et al.*, 2010) did not occur in the current study. As eigenvalue is a common method for factor extraction, it was considered for the same purpose in this study. In factor analysis, they are helpful determining criteria for retaining the most crucial factors to be considered in the analysis (K'Akumu *et al.*, 2013). The criterion used for consideration of significant factors was an eigenvalue greater than one. From the screen plot in Figure 3, it was demonstrated that the final solution occurs at a point on the vertical axis where the eigenvalue equals to one. Obviously, this was established after the fourth data point. This further confirms that only four components could be extracted.

4.4 Extraction of key drivers

The significance of a factor loading gives an indication, albeit little, of the substantive importance of a given key driver to a given factor. Generally, this significance depends on the sample size (Field, 2005). Spector (1992) purported that an obvious component structure is usually revealed when the factor loading of a variable is significant (loading > 0.5) on one component only. This was corroborated by Enshassi *et al.* (2018) who adopted a factor loading ≥ 0.5 for items included in each component (factor) using a sample size of 76. In

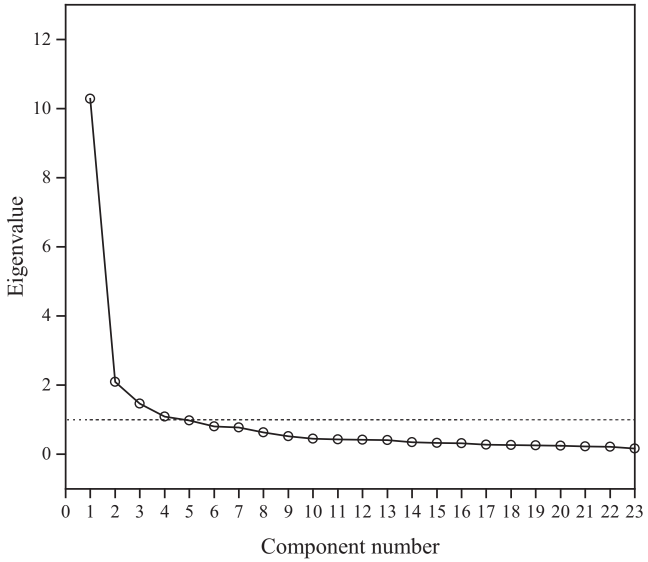


Figure 3.
Scree plot for drivers of EEM practices

Kline's (2002) opinion, key drivers with a factor loading of 0.30 or higher are considered important. For Brown (2009), key drivers having factor loadings close to 1 are clearly important in the interpretation of the factor, while key drivers with factor loadings near 0 are clearly unimportant. The factor loading in this study can be considered significant for the key drivers based on the submissions of Spector (1992), Brown (2009) and Enshassi *et al.* (2018). Each of the four principal extracted components and their respective key drivers with factor loadings are shown in Table IV.

5. Findings and discussions

From the result of the analysis, the 23 identified key drivers were categorized into four principal interpretable factors, namely, Factor 1: Raising awareness; Factor 2: Top

Table IV. Principal factor extraction and varimax rotated component matrix on the drivers of EEM practices

Factors	Nature	Description	Factor loading	Alpha (α)
Raising awareness	+	Creating and increasing general energy awareness	0.767	0.907
	+	Improvement of facility energy awareness	0.749	
	+	Education by research and development (R&D), teaching and learning	0.744	
	+	Community participation and collaboration	0.712	
	+	Provision of energy information	0.694	
	+	Understanding the issues	0.602	
	+	Commitment to continuous improvement	0.520	
Top management support and robust EM team	+	Apportionment of adequate resources	0.737	0.865
	+	Training provisions	0.709	
	+	Increase motivation by giving incentives in the form of awards	0.648	
	+	Leadership	0.618	
	+	Performing energy audits	0.609	
	+	Monitoring, review and verification	0.606	
	+	Operations and maintenance	0.599	
	+	Development and implementation of energy policy and reforms	0.571	
Risk management	+	Risk evaluation	0.862	0.906
	+	Development of a response to the risk	0.844	
	+	Risk identification	0.835	
	+	Development of preventive measures for the risk	0.802	
Stakeholders' participation	+	Good and effective communication among relevant stakeholders	0.718	0.863
	+	Trust among stakeholders	0.682	
	+	Knowledge and skill	0.658	
	+	Understanding the vision and goal of EM programme	0.620	

Notes: KMO = 0.935; 64.9% of variance explained management support and robust EM team; Factor 3: Risk management; and Factor 4: Stakeholder's participation.

5.1 Factor 1: Raising awareness

This factor accounts for 20.34 per cent of the total variance of key drivers of EEM practices in public universities in Southwestern Nigeria. This factor was named "raising awareness" because it contained items addressing issues related to awareness-based drivers for EEM practices in public universities. The seven key drivers of raising awareness as a factor were, creating and increasing general energy awareness; improvement of facility energy awareness; education by research and development, teaching and learning; community participation and collaboration; provision of energy information; understanding the issues; and commitment to continuous improvement. These seven key drivers had high factor loadings of 0.767, 0.749, 0.744, 0.712, 0.694, 0.602 and 0.520, respectively.

Many electricity users in the university are ignorant of the extent of influence their everyday actions and activities have on the excessive use of electricity. The goal of increasing general energy awareness is to help stakeholders understand how their actions affect electricity use. One of the advantages of increasing awareness is to obtain greater support for energy initiatives. Some of the tactics of increasing general energy awareness include personal (face to face) discussion, organizing energy-saving orientation programme (such as seminars and workshops), disseminating information on electricity use, environmental impacts and electricity-saving strategies intended for all stakeholders on the university's website or intranet and most of all, through sincere practice of conservation on the part of the university management at all times. Another means of increasing awareness and participation include communication of electricity savings realized.

Targeted efforts designed to improve awareness of the facility's electricity use are very important for the implementation and improvement of electricity saving strategies to achieve a sustainable university campus. Facility's electricity use awareness involves activities such as providing summary of energy statistics of university facilities including the overall electricity costs, costs to operate equipment, environmental information related to electricity use; providing information on the facility's energy sources and associated environmental impacts; providing electricity use information of equipment and activities regularly engaged in by all stakeholders; providing illustrative graphics that compare the facility's energy performance with a national standard (Affisco, 2012).

It is imperative to put in place a good energy education structure where basic electricity-saving strategies could be taught and learned. In fact, this finding matches Castleberry's *et al.* (2016) study where the authors reported a good relationship between environmental science courses offered in public schools and the implementation of energy-saving technologies and practices. The reason for this relationship may not be farfetched. A good energy education illustrates modeling concepts, whereby students, teachers and university administrators or management learn electricity saving behaviours from one another. Research and development (R&D) efforts in conjunction with industries should also be intensified to improve electricity-saving systems that will promote sustainable development in the university (May *et al.*, 2017). The present centres and institutions for R&D, teaching and learning and technology advancement should be sufficiently reinforced to support the shift towards better electricity savings. To achieve the desired sustained results, it is essential to include and urgently prioritize the development of personnel (human resource), critical knowledge and transfer of know-how as an integral part of the university's electricity saving programme.

The actions of the university community can contribute to the electricity usage pattern. Therefore, the community's engagement in the EM programme is vital for its overall success. The awareness of the university community can result in substantial electricity saving with little or no cost because the success of any EM programme depends on the participative interests it arouses in the stakeholders at all levels of the university community. Engagement of the university community can be improved by initiating and encouraging competitive electricity-saving targets for faculties, departments or residences within the university campus. Interestingly, all participants in the planning and implementation of a successful EM programme are usually motivated to share pride in the results.

Energy information has become an important instrument to achieve electricity savings. Its effectiveness increases as does the frequency in which the information is received (Abrahamse *et al.*, 2005). Electricity information can improve stakeholders' knowledge about their effective use of electricity (Matsukawa, 2004), encourage behaviour modification towards electricity use (Midden *et al.*, 1983) and motivate them to participate in EM (Maistry and Annegarn, 2016). Changes in sensing technology and energy infrastructure have enabled energy information to be collected, processed, and made available to stakeholders quickly, cheaply and often in real-time (Karlin *et al.*, 2015). Energy information may also include the latest technological advancements published in useful books, periodicals, reports and journals.

Lack of accurate understanding of the current situation before embracing any action plan would hinder the anticipated success of the EM programme. Therefore, the understanding of energy issues could stimulate efficient electricity savings. Both past and present electricity consumption trends must be compared and well understood to make suitable decisions that can enhance electricity savings now and in the future.

To ensure the survival of the EM programme in tertiary institutions, the importance of continuous improvement must be recognized. Continuous improvement is a systematic procedure for repeatedly seeking and implementing new and improved methods of EM (Bessant *et al.*, 2001; Wu and Chen, 2006). The purpose of continuous improvement is to build a capability to quickly and efficiently participate in process change of the EM programme. To develop such a capability, the top management must provide the platform needed to guide the setting of both the implementation and performance improvement of the EM programme. In addition, the sustainment of congruence between the goals of EM and the continuous improvement in the performance of EM programme and stakeholders in the university must be ensured.

5.2 Factor 2: Top management support and robust electricity management team

Top management support is the provision of a wide range of assistance for the EM team throughout the programme, as well as demonstrating both written and verbal support for the energy team. The support of the top management for any implementation has long been considered of immense importance in distinguishing between their ultimate success or failure (Schultz and Slevin, 1975). The degree of top management support for EM programme in tertiary institutions will lead to significant variations in the degree of acceptance or resistance to that programme (Manley, 1987).

This factor accounts for 18.02 per cent of the total variance of the key drivers of EEM practices in public universities in Southwestern Nigeria. The eight key drivers grouped under this factor – top management support and robust EM team – were, apportionment of adequate resources; training provisions; increase motivation by giving incentives in the form of awards; leadership; performing energy audit; monitoring, review and verification;

operations and maintenance; and development and implementation of energy policies and reforms; with factor loadings of 0.737, 0.709, 0.648, 0.618 and 0.609, 0.606, 0.599 and 0.571, respectively. Upon critical examination of these drivers' underlying characteristics and the fact that they fell within the purview of leadership and policy, the factor was named "top management support and robust EM team".

There is also a need to carry out further commitment actions in key areas. The top management must show a willingness to devote the necessary resources to make the electricity-saving programmes survive and successfully function for a long time. Investments in coherent and integrated electricity-saving strategies should be substantially increased and given special attention. The necessity of manifesting top management support is crucial during the planning stage as the EM team attempts to ascertain the availability of sufficient monetary, human, material and other resources to achieve a successful EM programme. Top management's commitment in the form of funding, other resources and creating accountability could ensure adequate adherence to this policy.

During the implementation of energy policy, training is a crucial factor that can change the attitude and behaviours of stakeholders pertaining to electricity use (Capehart *et al.*, 2006). Also, top management's commitment to provide training or more relevant educational programmes to all stakeholders is essential to ensure that the participants understand the process of the EM programme, and eventually increase electricity saving on campus (Kim *et al.*, 2019). The stakeholders must be equipped with the requisite skills and develop a commitment to perform their functions towards electricity saving on the campus. Well-trained stakeholders in the university's electricity saving scheme are more likely to contribute ideas and follow procedures, serving to guarantee that capital investments in electricity-saving strategies will realize their potential (Affisco, 2012). The training can be frequent or occasional and usually depends on the specific action plan of the university management, but it should emphasize performance improvement methods that will reduce electricity costs and environmental impacts. The periods of the training can also offer an excellent opportunity to gather participants' feedback and assessments and to receive and share professional knowledge. Finally, the training of stakeholders can facilitate strategic alignment of their efforts, improvement initiatives and long-term goals of the EM programme.

Significant contributions to the EM programme should be rewarded to encourage increased participation. The establishment of a reward and recognition system has been found to be a key to the sustainment of EM programmes. They can have either a negative or a positive impact on the 'discretionary effort' needed to be made by stakeholders to successfully resolve the problem of high electricity consumption in the university. Stakeholders could sabotage the EM programme when their participation is not valued and rewarded appropriately. Therefore, rewarding stakeholders' contributions must be at the heart of every EM initiative.

Good leadership is important for the success of EM programmes in terms of developing good EM policy and in administrating projects. Good leadership is essential to attract stakeholders' participation in campus electricity saving. The top management is at the apex of EM programme structures and has a dominant influence in determining its success. The top management is saddled with the ultimate responsibility for delivering the goals and targets of the energy policy. Leadership plays a connecting role between EM goals, stakeholders and continuous improvement of the EM programme.

The most vital part of EM activities such as the assessment of electricity consumption patterns and identification of electricity-saving measures can be achieved through energy audits (Haji-Sapar and Lee, 2005). An energy audit is a primary step towards improving electricity saving (Kong *et al.*, 2013). Energy audits can broadly be classified as *preliminary, targeted and comprehensive (detailed) audits* (Abdelaziz *et al.*, 2011). Each type is distinguished by the level of details involved and the depth of the analysis undertaken. It is important to select the appropriate audit type for the facility concerned.

Monitoring and analysis of electricity consumption are important factors towards a successful electricity management practice in universities because it provides decision support for identifying potential EM improvement opportunities and for understanding the impacts of these improvement actions on electricity use in different levels of a university campus (Boie and Kannan, 2003). The effective and successful implementation of any monitoring system should be supported by proper evaluation of performance and progress (Zilahy, 2004; Brundage *et al.*, 2016). Performance and progress evaluations are strong sustainability tools for ensuring the long-term success of any EM programme. An EM programme can achieve remarkable success at inception but become less effective over time. To guarantee and coordinate sustained success and continuous improvement, regular review and verification are required. This involves measuring, tracking and benchmarking to check that the energy targets and goals have been achieved or otherwise. The reviews should emphasize the progress made, difficulties encountered and potential rewards. The results of this review process should identify any necessary corrective measures and provide other needed feedback for subsequent planning and reexamination of the energy performance goals. It is also necessary to communicate the failures and successes of the energy programme to the top management of the university and other concerned stakeholders.

Maintenance and equipment replacement decisions are key contributors to the overall electricity costs on a university campus. To attain the goals of energy efficiency, the maintenance policies must dictate the type of equipment that should be used on the campus. Suitable equipment operations and adequate maintenance can be a very cost-effective option for achieving sustainable and energy efficient tertiary institutions.

Committed leadership is usually essential to encourage the actions needed to change the existing electricity situation in any way that is noteworthy (Capehart *et al.*, 2006). The starting point would be the formulation and implementation of an energy policy that must be driven from the top management to display ownership of this policy. The energy policy outlines the direction of the EM programme, and this must be clear and achievable. To track the performance and measure the progress, the implementation of the energy policy should be effective and supported by regular monitoring, evaluating, and reporting on energy situations. This should also be reinforced by EM best practices, which requires the collaboration of all concerned (Ihuah *et al.*, 2014). Another important consideration is that energy policy should be updated periodically.

5.3 Factor 3: Risk management

This factor accounts for 14.73 per cent of the total variance of key drivers for the implementation of EEM practices in public universities in Southwestern Nigeria. This factor comprises four key drivers, namely, risk evaluation; development of a response to the risk; risk identification; and development of preventive measures for the risk and their factor loadings were 0.862, 0.844, 0.835 and 0.802, respectively. This factor was labelled “risk management” because it included key drivers that are related to issues bordering on risk considerations.

A process of risk management is a cogent sequence of practices taken (by decision makers) to keep the implementation of the energy programme under certain conditions. The risk management committee need to identify, analyze and evaluate the risks in all the energy programme life cycle and proactively take actions based on risk information in favour of the goal and targets of the energy programme. A robust risk management programme can effectively take care of both existing and emergent risks.

A comprehensive list of identified possible risks must be created. The identification of risks is the most critical activity in risk management (Kwak and Stoddard, 2004). However, proper identification of nearly all risks before they occur can be accomplished by following the breakdown of the energy programme structure as a frame of reference. The identification of risks permits a more precise and reliable estimation of the risk level (Teller and Kock, 2013).

The identified risks must also be quantified, structured and prioritized according to the likelihood of occurrence, the importance of risk and impact of risk to allow the risk management committee to take appropriate decisions to reduce a potential loss or take advantage of possible profits.

Risk response measures should be adopted ex-ante to prevent the identified risks from occurring. The development of risk prevention measures helps to react more quickly to risks and enhances the capacity of top management to cope with risks. This would also increase the effectiveness of risk management. Response to risks includes avoidance of risk by embracing a change in the structure of the EM programme, transfer of risk in which external parties such as insurance firms are responsible for the risk, and mitigation of risk by decreasing the likelihood or impact of the risks. Paying attention to the causes of risks can reduce or remove the likelihood that the risk will occur. On the other hand, focusing on the consequences of risks would decrease the impact of the negative effect of risks if they eventually occur (Teller and Kock, 2013).

5.4 Factor 4: Stakeholders' participation

This factor accounts for 11.83 per cent of the total variance of the key drivers of EEM practices in public universities in Southwestern Nigeria. The four key drivers assembled under this factor were good and effective communication among the relevant stakeholders; trust among stakeholders; knowledge and skill; and understanding the vision and goal of EM programme. The respective factor loading for these variables was 0.718, 0.682, 0.658 and 0.620, respectively. Since these drivers are stakeholders specific, the factor was, therefore, named "stakeholders' participation".

The tasks in the EM programme are considered enormous for a single person to undertake. Therefore, the involvement of all stakeholders is another critical factor for sustainable electricity-saving/management practice. This group directly contributes to the benefits of electricity savings in tertiary institutions. The involvement of stakeholders in sustainable electricity saving of the university campus facilities is vital. The participants should expect to assist the EM team to achieve the programme target and should promote its sustainability.

The need for effective communication among relevant stakeholders is extremely important in creating an atmosphere for the successful implementation of EM programmes. To reduce inefficiency, communication is important. The EM plan must be communicated to the stakeholders at every stage. For the EM programme to be successful, the stakeholders must fully understand the impact of their involvement and the benefits of electricity savings. It is equally important to build a base of trust among stakeholders to agree with each other and harmonize their different views.

The success of the EM programme also depends on a more systematic and effective capture, dissemination, transfer and application of knowledge. Knowledge/skill acquisition and sharing provide a robust means for best practices, technologies, and operational guidance, which would ensure that the stakeholders implement EM effectively and efficiently. For example, in a recent study conducted in Oklahoma's public schools, Castleberry's *et al.* (2016) analysis suggested that districts that implemented energy-saving measures were nine times more likely to be knowledgeable or very knowledgeable in EM technologies and practices than districts that did not implement energy-saving measures. Stakeholders must, therefore, take advantage of various platforms to acquire, store and transfer information on EM techniques, skills and practices within the university community.

The goals and visions of the EM programme must be clear and understood, not only by the EM team but also by all stakeholders in the university. The vision determines the roles of every stakeholder in the implementation of the EM programme. Understanding the vision and goal is an essential element towards success. It plays an interconnecting role between strategic priorities of the university and EM initiative and may help sustain EM beyond initial rollout. This would ensure more effectiveness in driving resources to the EM programme to overcome problems that threaten its overall success.

6. Conclusions

EEM practices have the greatest opportunity to reduce the negative environmental impacts of universities. To encourage the widespread implementation of EEM practices, this study identified the key drivers for implementing EEM practices in public universities. This study contributes to the existing body of literature by focusing on the perspective of university stakeholders in Nigeria. A total number of 23 drivers were identified through a comprehensive literature review and presented in a questionnaire.

Afterward, a questionnaire survey was performed with university stakeholders in southwestern Nigeria to identify the key drivers of EEM practices from those included in the questionnaire. The top 5 out of the 18 most critical drivers based on relative importance assessment were understanding of the issues, understanding the vision and goal of EM programme, knowledge and skill, risk identification and good and effective communication among relevant stakeholders. The results from exploratory factor analysis of 1,182 responses clustered the 23 key drivers into four factors: raising awareness, top management support and robust energy management team, risk management and stakeholders' participation. The results indicated that raising awareness was a fundamental factor for achieving EEM in public universities. It is essential for the management of Nigerian public universities to take note of raising awareness as a key factor and also understand that it is the starting point for achieving EEM as it may increase stakeholders' motivation and support to adopt EEM practices. Therefore, there is a need for more and significant effort to improve the level of awareness and public consciousness among all stakeholders so that electricity can be used sustainably and efficiently in public universities. As for the top management support and robust EM team factor, it is believed that the findings of this study will assist the university management to lead by example by paying special attention to the provision of sufficient resources to ensure smooth operations and activities of the EM team. Besides, this key factor is crucial in ensuring a continuous congruence between the goals of EM and continuous improvement in the performance of the EM programme. Effective risk management practice is also a very important factor that would enable both top management and even the EM team to recognize the strengths, weaknesses, opportunities and threats of an EM programme, prepare for unpredictable occasions, and respond readily when they occur. How to handle potential risks must be clearly defined to ensure the effectiveness and success of any EM programme. It is, therefore, necessary to understand that proper risk management implies controlling possible future occurrences and is more proactive than reactive. Also, university management must consistently strive to encourage and boost the participation of stakeholders in the EM programme. In addition, stakeholders at universities must advance from a starting point focussed on awareness towards implementation, which involves a commitment to EEM.

The findings of this study not only contribute to a deepened understanding of the key drivers that greatly propel EEM but could also encourage the university management and other stakeholders to further implement EEM practices in the future to achieve a sustainable campus. The adoption of EEM practices needs consideration for electricity end-users to realize the benefits of EEM, such as developing buildings that are highly energy-efficient and have minimal environmental impacts.

The analyses of the drivers provide two interesting findings for public universities: firstly, they present significant drivers; secondly, they tend to give much greater weight to the awareness-related factor than top management and robust EM team, risk management and stakeholders' participation factors. Because this study endeavoured to present key factors that greatly drive the adoption of EEM practices, the empirical results have practical implications. The key drivers can be focussed on to effectively and efficiently promote and make decisions regarding the adoption of EEM practices. EEM campaigners can widely promote these drivers in the university community to influence the interest of university stakeholders to embrace EEM practices. Also, the management of universities can take the lead to initiate policies, plans and programmes that can boost the energy and environmental consciousness of university stakeholders and inform the public of the importance of and range of possibilities offered by adopting EEM practices.

Even though the objective of this study was achieved, it nevertheless has some limitations worthy of note and must also be considered when interpreting and generalizing the results. One limitation of the study is that about 60 per cent of the respondents were students and the level of significance assessment made in this study could be influenced by the respondents' attitudes and experiences, as it was subjective. Future research in Nigeria could be based on the results of this study to expand to more stakeholders outside southwestern Nigeria and compare the responses between stakeholders of different geopolitical zones. It is true that the findings of this study may be useful to policymakers and practitioners in other developing countries around the world, but different findings may be provided by data collected from another country. More cross-institutional similar studies could, therefore, be carried out in various countries using the proposed EEM drivers to identify region-specific differences. This would help to promote region-specific actions to uphold such drivers, as well as understand EEM policies that are most suitable for different countries based on the lessons learned in those countries and the mechanisms that could best catalyze the adoption of EEM practices.

While this paper only presents the results on EEM drivers, the future research paper would report empirical findings on critical failure factors of EEM. As a future study, approaches for overcoming the critical failure factors, and thus, encouraging wider adoption of EEM practices would be explored.

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Further reading

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