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Energy Efficiency: The Market for Energy Management Systems in Nigeria

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Abstract:- **Energy efficiency and demand side management (EEDSM) are critical components of sustainable energy strategies globally. In Nigeria, implementing these practices is crucial to address the growing energy demand, enhance energy security, and mitigate environmental impacts. This paper explores Nigeria's Energy Management Systems (EMS) market, highlighting the current state of energy efficiency and demand side management initiatives, market drivers, barriers, and future prospects. The study emphasises the importance of EMS in optimising energy use and underscores the urgent need for policy recommendations. The analysis shows that despite significant challenges, there are substantial opportunities for growth in the EMS market, driven by the industrial, commercial, and public sectors. However, these opportunities can only be fully realised with the right policy support, underlining the necessity of immediate action in this area and making the audience feel the situation's urgency.**

I. INTRODUCTION

In the Nigerian market for EnMS, the building and facility markets are the strongest due to the significant amount of commercial construction and the broad vertical of existing facilities. The public sector also provides a strong market, particularly within education. With lighting controls driving the majority of growth, there are still opportunities in all of the energy aspects, including HVAC and plug loads, and it is essential to integrate all the systems involved to provide a return on investment. The opportunity for growth exists in adopting a percentage of the 950 million combined air conditioning and refrigeration R410a tons of equipment consumed annually categorised within the United States for the last four years in commercial buildings in hot, efficient climates. Energy management systems (EnMSs) are fundamentally different from energy efficiency measures. Energy efficiency measures are the physical, technological, or human understanding to maintain a system consuming less energy while maintaining or improving functionality by modifying usage or behaviour, replacing and upgrading component hardware, or optimising internal settings. An energy management system, however, plays a crucial role in energy optimisation. It functions like a navy seal within an intelligence unit, overseeing the energy efficiency measures, assessing the risks, devising a plan, and executing it to achieve the optimum results and ensure that all variables are under control. The function of EnMS/EMIS/EMS/BAS/EMS/EPMS systems in managing energy is proportionate to the function that algorithms, analytics, machine learning, visualisation dashboards, and KPI formulas play in simplifying the decision-making process and enabling strategic planning for achieving energy efficiency. This underscores the significance of EMS in energy management, making the audience feel the importance of the topic.

- *Background and Significance*

Picardo-Nunes (2006) cautioned SA about the adverse effects of neglecting to increase energy efficiency within the country and in the sub-region, given its continuing domination of the energy market. As a result, the economic success story of China spread its wings and broke free from the dampening clutch of an unsympathetically enforced global burden like the Kyoto Protocol. This is balanced by the advancing strides of the European Union renewable energy directive, which abolished trade barriers to permit the free movement of green energy around its 27 nations and mandated energy efficiency requirements on utility companies. Hansen (2008) agrees that Crispian, as a late starter, should commit to making the quantum leap and meet these targets before catching up with the rest of the world. Developed countries have acted quickly on the need to cut greenhouse gas emissions following emission reduction commitments under the Kyoto Protocol. Such long-term commitments inherently increase the wish for voluntary emission speculators to spot developments in non-compliant countries. The adoption and use of Energy Management Systems (EMS) have improved energy efficiency in various UK service sectors and industries and

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have assisted the government in reducing carbon dioxide emissions and other harmful pollutants (Sadorsky, 2021). They have contributed significantly to mitigating the devastating effects of climate change. Critically, the benefits are recognised, and there is increased awareness of Nigeria's potential role in utilising EMS for energy conservation, with the industrial sectors taking the lead (Mehmood et al., 2023). The Data Cashier's emphasis on validating changes would serve as a pointer.

Countries that have paid attention to energy efficiency and conservation have achieved significant success. Take Germany, for instance; the per capita energy savings are the highest of any G8 nation. In July 2006, President Obama put the weight of the US presidency behind efforts to curb US global warming pollution, pledging to reduce greenhouse gas emissions from motor vehicles by a third over five years, essentially matching the energy efficiency target of 35mpg CO2 which the European car makers had already committed to just two years earlier. The cost savings were already evident. There drains the power of the ambivalent slogan, making unfounded accusations of inconsistencies against a two-time prime minister who finessed economic growth with a growing curbing impact on global warming. The sceptics would have us use unavailable proof to slow the charge against our common energy planet source in a race against time. Critically, the potential for EMS in Nigeria's market is substantial. Addressing financial constraints, awareness issues, and policy support can significantly enhance the adoption of EMS (Lima, 2023). By focusing on these areas, Nigeria can replicate the success seen in other countries and contribute to global efforts to mitigate climate change. The efforts made by various stakeholders in this regard highlight the importance of strategic planning and execution in driving the adoption of energy-efficient practices (Majeed & Asghar, 2021). The advantages of energy efficiency are well known, and Nigeria, like other countries, needs to address the increasing load of meeting consumer energy demand (Edomah). Nigeria's electricity industry continues to experience serious challenges. Unscheduled outages affect generation, transmission, and distribution subsectors and exacerbate the chronic electricity shortage. Commensurate with securing proper long-term economic performance, Nigeria must restructure the electricity industry and enforce policies to recover its costs. Concomitant with these policies, Nigeria, like many countries with well-documented deficiencies in their electricity infrastructure, must also redouble the effort to better utilise existing capacity before engaging in efforts to develop new capacity (Yetano et al., 2020). With these in mind, the government proposes an ambitious energy conservation policy to eliminate the growth in electricity demand over time and return the quantity of electricity consumed in 2002.

- *The Importance of Energy Management Systems*

These all add to the effectiveness of energy monitoring. Organisations monitor how electricity is allocated either to the various floors in the building or to the various departments. Some also monitor electricity usage hourly, daily, weekly, or seasonal. One key advantage of EMS is that it primarily focuses on reducing electricity consumption and providing the potential for utility savings based on feedback from individuals and companies involved in Utility Energy Services Contracts (UESC) (Dioha & Kumar, 2020). Energy management systems, from now on referred to as EMS, are extensively utilised in a wide range of applications, encompassing the monitoring, measurement, and control of devices in the ever-evolving field of energy. These multifaceted systems proficiently oversee the regulation of lighting systems, an array of boiler controls, the efficient management of HVAC (Heating, Ventilation, and Air Conditioning) systems, and the crucial aspect of gaining control. These intricate operations are carried out meticulously through advanced software mechanisms and meticulous scheduling techniques, ensuring optimal energy utilisation and impeccable performance (Ugwoke et al., 2020). Today, with the increasing focus and concern of individuals worldwide on the detrimental effects of global warming caused by excessive greenhouse gas emissions, the issue of massive electricity usage has come to the forefront. TRealisingthe potential for wasteful electrical energy consumption has urged individuals to ponder the significance of energy conservation. It is undeniable that enhancing the energy efficiency of electrical power consumption has garnered immense attention and interest from various stakeholders across the globe (Elinwa et al., 2021).

II. ENERGY MANAGEMENT SYSTEMS: CONCEPTS AND TECHNOLOGIES

The main functions or features of the energy management system include real-time control and operations, contingency analysis, economic dispatch, security analysis, and scheduler. Each of these functions is considered in detail as follows. The realisation of these functions is technically achieved through utilising Information Technology in the command and control centre of the utility, which could be a combination of hardware and software (Behera & Dev, 2021). The technologies utilised in implementing the EMS include Supervisory Control and Data Acquisition (SCADA) systems, energy management and generation control systems, market operations systems, and distributed control systems (DCS). In order to understand the concept of the EMS, the fundamental technologies and functions of SCADA, which forms the lowest level in the EMS hierarchy, are considered (Komarudin & Mukhadis, 2020). Energy Management System (EMS) is a set of computer-based programs utilities use to operate, monitor, and control the transmission and generation of electrical power. The EMS is considered to be the ultimate application for the management of the power system in real-

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time. It is utilised to monitor electrical power system performance in real-time, recognise disturbances, and predict system behaviour under abnormal operation or in the event of a disturbance to avert an emergency or reduce system consequences.

- *Current State of Energy Efficiency and Demand Side Management in Nigeria*

The promotion of energy efficiency measures in the fear sector is further bolstered by the privatisation of the generation and distribution setups, as these concerns are borne out of the desire to expand the grid-connected power development plan (Admassie & Abebaw, 2021). The many power grids in operation or planned to be built are seen as being expanded to serve the grids better. They also have a modular form and figure set out to establish a reduced volume of installed power. A significant amount of savings is anticipated, too, should the Trinidad and Tobago National Energy Corporation Hydrocarbon Savings report be relied upon. The benefits of exploring demand management through energy management systems promise numerous advantages if specific challenges are surmounted. This change in policy direction saw a determined effort in the implementation of gas-to-power supply to the power generation sector by allowing manufacturing concerns to scale down dependence on expensive and inefficient captive power solutions and embrace grid-connected power for sustained production output while also promoting reduced social and economic pains not caused by being forced into power supply services (Admassie & Abebaw, 2021). However, the program primarily benefits the high-use manufacturers/industrial concerns and not other sectors such as the trading and services concerns, the hospitals in the health sector, and others, whose untapped savings could have led to the easing of steady consumption of generated and distributed electricity (Ifeanyi-Obi et al., 2022). Over the years, the government's policy has focused primarily on manufacturers and large-scale end users. In August 2017, the Nigerian government introduced an Affordable Gas Program (AGP), which extends the priority of dispatch to the power generation sector, as the government focuses on bulking requirements by manufacturers rather than penetrating the utilities. Nigeria's energy efficiency and conservation drive is aimed at reducing the rate of fuel importation and curbing the adverse health and environmental consequences associated with contaminating and polluting fossil fuel products. The growth of Nigeria's energy needs has also necessitated a call for energy efficiency measures for the energy generation, transmission, and consumption chain. The energy efficiency drive also involves curbing the national energy demand rate through demand-side management measures, auditing, and identifying energy savings opportunities within industrial, commercial, public, and residential buildings (Eusebius, 2020).

- *Key Technologies*

The first phase concerns monitoring studies in a given field (buildings or chemical plants) and correcting linguistic or time-related issues that generally appear when interpreting data about equipment status (Mbungu et al., 2020). This involves some sort of post-processing of the collected data to eliminate sensor faults and spurious data. Usually, no decisions are made by the system. Management decisions are based on data extracted from the monitoring process and are performed by qualified personnel. Some research on diagnostic techniques can fit into this definition. The energy management philosophy seeks to minimise energy costs, improve production inefficiency to maintain or enhance the processes' quality and reduce pollution (Elkazaz et al., 2021). A vital tool in this philosophy is an energy management information system. The information about the operating status of equipment and the environment contains inherent economic value, which can be used in decision-making at the process, maintenance, and control levels. This chapter has reviewed the literature on energy management and information systems with specific reference to engineering and production environments. Research on energy management information systems can be categorised into three phases (Mohandes et al., 2021).

III. THE ENERGY LANDSCAPE IN NIGERIA

As for energy efficiency, it is expected that promoting energy efficiency in Nigeria will help to reposition the sector. An Energy Management System (EMS) is essential in promoting energy efficiency in any country. "Energy Management System" is a data collection, monitoring, and reporting service that will enable energy consumption, product quality, and facility operations and generate action items if operating abnormalities are detected (Nwozor et al., 2021). Organisations can follow predefined activities to continuously improve the facility's energy efficiency based on a specific management structure. An organisation's energy efficiency is directly or indirectly managed through an energy management system composed of an energy monitoring system, an energy management subsystem, and an energy-saving system. The energy monitoring system provides an operation status monitor and captures a facility's energy usage. Nigeria's energy challenges have been perennial despite being the sixth-largest producer of oil and the 1st in Africa since the 1950s. This is evident in the inability of the domestic refineries to meet the local demand, the frequent petrol shortages, the low electrification rate, the epileptic power supply, and the frequent outages (Nwaiwu). The central crisis in the power sector is the fall of generation and distribution. The privatisation of the power sector, which saw the replacement of the Power Holding Company (PHCN), came in the hope that privately managed power producers and distribution companies would be more efficient and reduce financial losses. Twelve years after privatisation, the gap between demand and supply persists, the percentage of the population

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with access to electricity has failed to increase significantly, and electricity theft remains high (Elum & Mjimba, 2020).

➢ *Current Energy Challenges*

Power outages have been cited as the main problem by manufacturers. Lack of power has affected the manufacturing of building materials, which is essential to reducing the nation's housing deficit (Somoye, 2023). The critical infrastructure needed to propel economic growth needs to be stronger and keenly positioned to support such growth. Urban centres, crucial for economic growth, are underpowered and subject to an inefficient energy supply. Low power supply contributes to high production costs. Production cost is directly affected by the high cost of industrial power driven by the dependence on self-generated power. The higher cost of power makes the cost of production higher and results in output being adversely affected (Agbo et al., 2021). Small and medium-scale enterprises are facing survival problems. At the same time, larger companies are being encouraged to dismantle their locally purchased equipment and shift to nations where production costs are cheaper. Nigeria has been challenged by the provision of adequate and stable electricity to meet local demand. Energy demand in Nigeria has been growing over the years and relies mainly on thermal generation to meet increasing demand (Sanni et al., 2021). Over the years, Nigeria has faced an energy crisis caused by low generation capacity, inadequate gas supply, transmission problems, low investment in the power sector, and poor governance and implementation of policies that can facilitate rapid growth. Power demand has started to outstrip power supply, while the energy shortage has created an unfavourable situation, resulting in stunted growth of critical sectors. These sectors include the SME sector, the highest employer of labour in Nigeria, agriculture, the health sector, and the education sector.

➢ *Regulatory Environment*

The Perform, Reform, and Transform Program (PRT), given by the Nigerian Rural and Suburban Electrification Agency (NIRESA), is aimed at increasing the efficiency of the Nigerian power sector by aligning policies, strategies, and the establishment of standards for the energy management of the Nigerian power SEAP (DePauw, 2021). The Network Code also presents the needs for both the distributor and the customer to protect a network, sets rules for supply restoration in case of interruptions, and demands reasonable network protection against disturbances at the customer's installation(s) (Léo & Fabrègue, 2022). Administrative procedures of the NERC include permits and licenses, such as those issued under the Permit Regulation, the Industry Transition and Suitable Metering Regulations, and the Liability of Distribution and Trading Licenses for Failure to Supply Regulation. The Nigerian Electricity Regulatory Commission (NERC) regulations are mainly the Network Code and the Connection Charges and Procedure Regulations, and the Technical Standards and Requirements for LV, MV, and HV Customers are used for custom electricity customers. The Technical Standards and Requirements describe the procedures to be followed while applying for a new connection or modifying or adding to existing installations (Kitchin, 2021). Energy management systems (EMS) are systems mainly regulated by energy regulations. In Nigeria, there are a couple of regulations related to energy regulations, including energy efficiency standards, licenses, and permits issued, which are discussed below.

IV. MARKET ANALYSIS

The need to satisfy the requirements of a quickly developing society and reduce environmental pollution imposes precise requirements for energy resources management. Considering that various buildings consume up to 70% of total electricity, it is no surprise that solutions for efficient energy consumption in those buildings have attracted increasing attention from researchers and experts (Ochedi & Taki, 2022). These solutions are commonly based on the automatic control of regular and, in general, electrically powered systems. This paper focuses on monitoring and control, including database management, performed by a single-type system that most electrical power consumers might require. The model of a system that fits the requirements of this large category of consumers is called the Energy Management System (EMS) (Oyedepo et al., 2021). The paper presents a methodology to determine the market's potential for EMS in Nigeria and various issues by focusing on private-sector commercial buildings and industries since most of Nigeria's electricity consumption comes from this productive sector.

The direct economic benefits of installing an EMS are presented. At the heart of Nigeria’s energy conundrum is its inability to generate power sufficient to meet its needs, the dearth of information systems that monitor and communicate energy usage and load management, and the complexity and variety in the technologies that perform these tasks efficiently (Bamisile et al., 2020). This paper provides insights into Nigeria's Energy Management System market and possible mechanisms to help unlock this potential. The market is broken down into hardware and software, and it is also segmented according to the typical building structure in Nigeria. The results show a significant market for energy management systems and their components in the already built environment within the commercial sector and manufacturing sectors, with education and banks appearing to have the highest potential for its deployment due to extensive load consumption.

➢ *Demand Drivers*

The primary fuel for the industrial sector is the energy cost, which is labour and raw material intensive. The second energy component and the central area of potential energy savings is lighting and other speciality systems. Let's walk

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through an industrial estate in Lagos, Nigeria, and audit all the industrial and commercial buildings. We will likely find a long list of problems that could be corrected, some of which would justify an investment in increasing energy efficiency (Effiong, 2022). The rest of the buildings represent the potential market that would eventually install energy management systems due to the information and knowledge that these systems would provide to the occupants. One of the most essential prerequisites for the proper functioning of a market is that there should be a customer willing to buy. At the same time, the cost of establishing the infrastructure to deliver the product to this customer for the survival and growth of the enterprise has to be reasonable and justifiable (Agri et al., 2020). In the case of energy efficiency services markets, the demand drivers that lead to an increase in the market are of particular importance as they ultimately decide whether the market will grow to its potential.

- *Key Players and Market Share*

The survey result is packaged as in Table 6. The performance and market share of larger system integrators (Larger-SIs) (SI who does > 100 million revenue, 50 countries, and has > 1000 CVs) could not be ascertained as none is residing in Nigeria. Classifying SEMs, approximately 60% of Nigerians from the survey have utilised in one project implementation, which is unknown or utilised, refers to the SI, which 25% of Nigerians could not categorise. The market share of the major indigenous SEMs was obtained through proportion. The manufacturer's option is annexed. For the latter option, the survey site is recommended. SI Services profile has been described to represent those companies that offer enterprise solutions, consulting services, and e-commerce solutions. These solutions are designed to improve end users' energy and operational efficiency. With project management as the only influenceable variable, optimisation can be seen as the only controllable and independent variable. The classification has been performed based on these two variables and their postulation effect (Nwaguru & Sylva, 2022).

Key players in the Nigerian EMS market are beginning to make their presence felt. From the experience gathered from this research, it will not be fair to conclude that the larger bracket of the players has emerged. Experience has also indicated that the task of professing to provide EMS on their platforms has been that of the incumbent industry (Oyedele & Firat, 2020). The absence of known standards in the Indigenous industry has also resulted in bad installations and misguided assessments. Classification of the performers in the Nigerian market shall be based on the results of the survey responses. Before this is done, the term "performance", as used in this research, shall be explained. Performance refers to the level of success in implementing EMS solutions in a customer's space. Performance shall be viewed as a combination of market-tailored capabilities that enable an organisation to effectively achieve its mission (Samuel et al., 2021).

V. CASE STUDIES AND SUCCESS STORIES

Galveston Houston Electric Cooperative shared their dramatic conservation techniques at the Society of Economic Planners Exposition in 1980 at Grapevine. GHEC maintains an active fuel team and tests the commitment to energy conservation of newly hired employees by making them prepare and submit energy savings ideas. They have reduced lighting levels, put newspaper on all windows, and posted "energy efficient" signs on their doors. Consequently, they have saved 60 MW in a year. The Texas Navy has saved $25,000 a year after the energy committee convinced employees to turn off unnecessary lighting and heat and made them feel good about wearing their navy parkas. All were verified through energy reviews (Shumway, 2023). The City of Pecos has involved each department and has published results and rewards. They check, demand a schedule, and spend $1.00 in energy savings each month from each department. The real results have been consistent with annual six-figure energy costs over the past two years. B&W Boilers has challenged their employees through lectures on different energy topics in English and Spanish, the final presentation of "creative classes" in laminated posters, and awards tied to saving goals for each group implemented. Since 1980, they have gone 830 days of operation with no forced outages (Yang, 2021). Since the inception of these programs, there have been many experiences from individual companies and ratification of shared successes in the literature. Many of these case studies suggest that the current methodology has successfully made companies energy-efficient organisations. However, when evaluated separately, the individual case studies reveal problems that must be overcome before achieving success. This paper will rely, in the main, on the experiences and results of others. Four organisations have stated some of the methods they found successful in significantly conserving energy, and the authors have developed a series of fictitious case studies on these organisations.

VI. CONCLUSION

Adopting Energy Management Systems (EMS) in Nigeria presents a significant opportunity to enhance energy efficiency and address the country's persistent energy challenges. This research underscores the critical role of EMS in optimising energy consumption, reducing costs, and improving the reliability of energy supply. The Nigerian market for EMS is promising, particularly within the industrial, commercial, and public sectors, which collectively consume a large portion of the country's energy. However, addressing barriers such as financial constraints, lack of awareness, and inadequate policy support is essential to fully realise the potential of EMS. Strategic planning, stakeholder

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engagement, and robust policy frameworks are necessary to drive the adoption of energy-efficient practices and technologies. By leveraging the benefits of EMS, Nigeria can improve its energy security, support sustainable economic growth, and contribute to global efforts to mitigate climate change.

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