

# The Internet of Energy's Impact on Revolutionizing Academics and Administration in Tertiary Education

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*Abstract- There is enormous value in connecting the unconnected with smart networks across tertiary institutions. The Internet of Energy (IoE) has emerged as a promising technological paradigm, presenting new opportunities for revolutionizing energy management and sustainability in tertiary education institutions. Through an in-depth analysis of IoE implementation, challenges, and benefits, this paper demonstrates to contribute valuable insights for educational stakeholders to foster a more sustainable and efficient learning environment. The adoption of the IoE in tertiary institutions has a positive influence on excellence in teaching and learning, efficiency in bureaucracy and managerial activities, and maximizing energy efficiency by minimizing losses, energy consumption, and its effect on climate change. It also established the potential impact of making education more relevant, engaging and motivating learners, and thus enabling a faster time to mastery.*

*Index Terms – Climate Change, Energy Efficiency, Internet of Energy (IoE), Smart Networks, Tertiary Education*

## I. INTRODUCTION

The monolithic developments and the broadened role of technology placed a remarkable influence on almost every sphere of life, especially during the COVID-19 pandemic. Similarly, the domain of education has also confirmed its growing tendency to adopt the changes underlying technological advancements to strengthen the teaching and learning process, as traditional and outdated methods are no longer attractive to learners of the advanced era (Patel and Keyur, 2016).

The energy trilemma (energy security, environment, and economy) has become a concerning element of the modern world (World Energy Council, 2012).

The increasing demand for electricity considerably leads to power quality degradation, network congestion problems, and thus a lack of energy security. Electric energy poverty occurs when the supply of electric power falls below demand or expectations. In spite of the poverty, there is also epileptic technical performance due to the many critical shutdowns and fluctuations that occur in power networks, affecting many economic sectors (Iwuamadi, Dike, and Iwuchukwu, 2014).

Inadequate electric power security in Nigeria has imposed significant costs of more than a 400% increase in sectors of the Nigerian economy, and the bulk of these costs come in the form of the sustenance of very expensive backup power (Iwuamadi, Osondu, Anyaehie, and Iwuamadi, 2020).

The education sector is no exception, but the impact of power outages (planned and unplanned) on critical infrastructures like databases, research processes, etc. is somewhat neglected. Tertiary education institutions incur very high costs to provide a daily alternative and efficient source of electricity as energy-intensive organizations with diverse academic and administrative needs, making them ideal candidates for harnessing the potential of IoE technologies.

Most educational institutions in Nigeria, with Federal Polytechnic Nekede as an example, are currently operating on two major modes of power supply: utility and local generators. The frequent failures and unavailability of supply from the utility source have made the institution depend mostly on local generators for electricity supply to most of its facilities. This development has led to the institution running different generators for different facilities,

and as a result, there are 32 different generating sets with varying capacities running simultaneously almost daily (Anyachie and Iwuamadi, 2020). The high cost of fueling and maintaining these generators can be imagined.

The rapid growth of smart devices, renewable energy sources, and advanced data analytics paved the way for high energy loads with added connectivity to the Internet and ultimately corroborated the Internet of Energy (IoE) to lower energy requirements through intelligent, practical, and controlled usage.

The Internet of Energy is a technological term that refers to a technology that links power generation, distribution, and consumption to optimize energy use and lower costs (Bui, Castellani, Casari, and Zorzi, 2012). It uses IoT technology to collect and manage data and operations at multiple points within a power grid structure. IoE combines the features of the smart grid and the Internet of Things (IoT). IoE allows energy production to move forward more efficiently and cleanly with the least amount of waste. The IoE has empowered large-scale digital transformation in the energy sector to operate real-time applications with low and efficient intakes (Aldowah, Rehman, Ghazal, and Umar, 2017).

Through an in-depth analysis of IoE applications, challenges, and benefits, this research seeks to contribute valuable insights associated with IoE implementation in higher education institutions to foster a more sustainable and efficient learning environment. This paper aims to explore the potential impact of IoE implementation on revolutionizing academics and administration in higher education.

## II. LITERATURE REVIEW

The transformation of pure physical objects into smart objects marked the past decade; everything that surrounds us is connected to a network and produces data, a valuable form of currency that positions educational institutions, researchers, and scientists as powerful players in the economy (Abdel-Basset et al., 2018; Siebel, 2019). In this advanced era, also called postindustrial society (Siebel, 2019), the changes are technologic and societal, where the focus is on the smart and efficient delivery of services and the shift

from mechanical or muscle energy to information power. Abassy and Quesada (2017) highlighted the fact that with IoT, it is possible to connect different objects (machines and/or humans) remotely and execute actions that otherwise would be time-consuming to execute. IoT allows a connection across different institutions and provides a broader level of connectivity between humans (H2H), things (T2T), and humans and things (H2T).

Smart campus systems have become a central part of sharing and accessing information, and the demand for digitized content and activities has seen a significant increase over the years (Coccoli et al., 2014). These systems allow easily accessible information as well as teaching, learning, working, and researching in a digital environment. A physical campus that fully integrates technology will enhance the students' experience by offering suitable environments and layouts for different educational purposes (Abdel-Basset et al., 2019). However, the technology does not only benefit students, lecturers, and professors by offering tools; a digital campus can also reduce its operational costs and enhance security thanks to the IoE applications. The four main categories that allow the benefits of these novelties addressed by Aldowah et al. (2017) and Kassab et al. (2020) to take place may include ID cards that allow for automatic attendance, monitoring of security systems, tracking of goods and equipment, self-adjusting lighting adapting to outside natural light data, and time-adjusting appliances adapting to temperature data, which reduces electricity costs. Anyachie and Iwuamadi (2020) proposed an efficient energy management system (EMS) for the Federal Polytechnic Nekede to reduce the running and maintenance costs of providing sustainable electricity. The EMS would time and allocate power to electrical loads and facilities based on priority. They also proposed a zoning arrangement that will greatly reduce the number and installed capacity of active generators running on the campus to 5 and 1850 KVA, respectively.

However, the integration of renewable sources into utility grids faces the challenge of controlling mechanisms with storage facilities (Tan, Li, and Wang, 2013; Han, Solanki, and Solanki, 2013). Furthermore, the efficient utilization of generated

electricity is an essential consideration in revolutionizing academics and administration in tertiary institutions. Hence, an Internet-style solution called the Internet of Energy (IoE, or energy internet) has been proposed as an extension of the smart grid for the investigation of the bidirectional information and power flow of electricity.

### III. APPLICATION OF THE INTERNET OF ENERGY IN TERTIARY INSTITUTIONS

The energy management system works to assess the operating status of energy sources. A microcontroller-based energy management system illustrates the potential architecture of the IoE communication network by which monitoring and control of activities of energy flow, such as lighting, heating, ventilation, and air conditioning, electrical appliances using an automatic transfer system (ATS) and/or setting time schedules for their operation (Anyaehe and Iwuamadi, 2020), are accomplished. The IoE advances changes in the face of every field of life by turning every object into a smart entity. This is also true for the education environment where one encounters a true chain in which energy smartly passes from smart campus, smart building management, smart classroom, virtual learning environment, energy-efficient campus infrastructure to IoT-enabled assessment technique. The description of numerous integration of the IoE in a Smart Campus is as shown in Fig. 1.

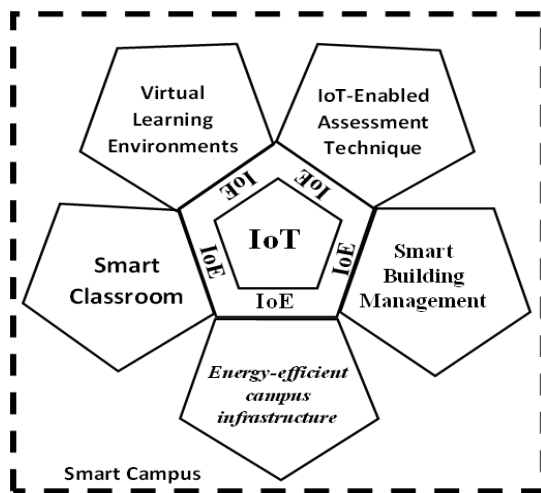


Figure 1: Integration of the IoE in a Smart Campus

Smart sensor networks have the advantages of low cost and easy access, thus creating the opportunity for large-scale implementation in the smart grid.

#### i. IoE Implementation in Academics

IoE implementation in academics will revolutionize tertiary education with prioritized and sustained electric energy flow in smart classrooms, virtual learning environments, IoT-enabled assessment techniques, and collaborative learning platforms.

a. Smart Classroom: A smart classroom is the space that accommodates all the education activities based on electronic devices such as digital screens, video projectors, internet-connected devices, facial recognition algorithms, and other modules that monitor various parameters of the physical environment (Shrinath, Shivani, and Shruti, 2017; Xie, Shi, Xu, and Xie, 2001). Creating an intelligent environment using AR-enabled (Augmented Reality) wireless smart whiteboards and interactive content, note-taking digital textbooks, and virtual reality headsets could completely reshape the classroom experience for students.

b. Virtual Learning Environments: Smart teaching differs from traditional teaching, especially in the way in which content is conveyed by means of various electronic devices. Moreover, the content is always available, and learning is adaptive (Shrinath, Shivani, and Shruti, 2017). Through sensing devices, the IoT may offer access to the real world, which turns the teaching process into a challenging experience as it has to be tailored and adapted, involve different teaching approaches, and address students that are faced with learning challenges (impaired vision, hearing, locomotion, and hyperactivity disorders) (Savov, Terzieva, Todorova, and Katarova, 2019).

c. IoT-Enabled Assessment Technique: Smart assessment exceeds the traditional assessment framework, which is based on multiple-choice tests or the development of knowledge. In a smart context, assessment becomes an inescapable process based on ICT and evolves in the context of an actual IoT ecosystem (Farhan et al., 2018). Modern learning systems must integrate adequate

instruments able to capture students' behaviors into the assessment strategies of online learning. Smart assessment should include instruments and methods to detect fraud, AI-aid, and plagiarism (e.g., to detect whether solutions are copied from the internet), as well as cases when students learn by heart the solutions to exercises, which may only mimic the internalization of knowledge in an examination (Averill, Recktenwald, Roccabianca, and Mejia-Alvarez, 2020).

d. Collaborative learning platforms: A collaborative learning platform is a web-based software program designed to accommodate the various learning and development needs of an educational institution at scale. The main focus of these learning solutions is that learners can share knowledge and interact with one another from anywhere. Teachers and students can use the platform to interact in real-time as they work towards unified learning goals. Some examples of collaborative learning platforms are Google Classroom, Class123, ClassDojo, Schoology, Canvas, Edmodo, Blackboard, and Moodle. Among other features, these platforms include discussion forums, group workspaces, and communication tools such as chat rooms.

ii. IoE Integration in Administration

A critical part of implementing IoT is integrating the operations of an interconnected network of equipment in various buildings within the premises. The IoE can optimize and streamline administrative processes within tertiary institutions through an energy-efficient campus infrastructure, smart building management, and smart campus operations.

a. Energy-efficient campus infrastructure: Higher education institutions can retrofit dated HVAC systems and lighting fixtures such as high-pressure sodium (HPS) lamps with LED luminaires, which can save 10–25% of total greenhouse energy demand (Katzin, Marcelis, and Mourik, 2021) and prove to be an effective and easy way to reduce energy costs and operations and maintenance costs. Relying on clean energy sources on campuses, including geothermal, solar, wind, biomass, and others, to meet energy needs can help educational

institutions create sustainable and green infrastructure and reduce carbon footprints. Developing energy innovation plans with long-term sustainability goals is a proactive approach to reducing the energy intensity of buildings on campuses and lowering overall emissions.

b. Smart Building Management: Educational institutions have not considered focusing on unifying the built environment through Internet of Things (IoT) technology. IoT can help make campus buildings and zones more responsive by determining specific requirements such as lighting, temperature, and humidity and adjusting the functioning of equipment accordingly. Intelligent building management platforms implement IoT, identify building occupancy patterns, and monitor the functioning of such networks of equipment around the clock with exhaustive data on the energy consumption of various equipment (Li, Yang, and Lam, 2013). Poorly managed and improperly controlled building management may significantly increase the amount of wasted energy in a building's energy economy. It is a challenge to gain greater visibility over the functioning of equipment across every part of the campus and optimize operations to reduce energy usage. IoE-based SBM helps reduce building energy consumption by exchanging information on energy demand and supply, thus reducing energy consumption for sustainable smart buildings. Developing energy innovation plans with long-term sustainability goals is a proactive approach to reducing the energy intensity of buildings on campuses and lowering overall emissions.

c. Smart Campus Operations: IoE provides a sustainable energy framework that meets needs as a replacement for traditional manual operations; thus, it automates processes, reduces operational costs, and increases efficiencies. Federal Polytechnic Nekede, by introducing an Enterprise Resource Planning (ERP) system, IP Surveillance Cameras, Mobile applications, and all-round internet access, has paved a basic pathway for IoE

implementation to aid academic excellence and administrative efficiency.

#### IV. ENERGY SUSTAINABILITY AND COST EFFICIENCY

Anyachie and Iwuamadi (2020) proposed that EMS using the zoning technique at Federal Polytechnic Nekede will reduce the number of generators from 32 to just 5, thus reducing both operational and maintenance costs. This approach will barely mitigate carbon footprints and costs, but it cannot sustain the energy it consumes. Relying on clean energy on campuses to meet energy needs will help educational institutions create sustainable and green infrastructure and reduce carbon footprints. The main aim of the IoE implementation in tertiary institutions is to optimize efficiency, reduce energy consumption by balancing demand and supply, and reduce significant amounts of GHG emissions to develop a sustainable environment (Olivier et al., 2016). This optimization of energy through digital tools like sensors, actuators, and computers, to name a few, is expected to reduce costs and also increase reliability in delivering power to homes and businesses alike.

Apart from cost savings, clean energy projects have been pivotal in providing learning, training, and research opportunities for students. An additional benefit will be to eliminate wasted power generation by informing energy producers when systems are at maximum capacity or in low demand.

#### V. CHALLENGES AND SOLUTIONS

Today's technologies give us limitless possibilities, and even though the use of IoE applications in education is still associated with some difficulties, such as high cost or security issues, as they improve, all these barriers will certainly be removed. It is very important to identify potential challenges associated with IoE adoption as well as possible solutions that can help surmount these challenges.

- a. High Implementation Cost: Financial resources play a crucial role in the integration of IoE devices and software in the education environment. These expenses

include not only the initial expenses of purchasing hardware, software licenses, and the maintenance price of IoT tools but also spending on a sustainable power supply and teacher training. Also, the cost of providing sufficient bandwidth and reliable Wi-Fi connectivity—all these could be the most challenging issues for public-funded institutions, requiring a lot of resources given the scale of implementation. Institutions must be genuinely willing to appropriate funds and expertise to effectively and efficiently automate both administrative and academic processes. Another option is to order a custom solution from a vendor with extensive experience, which allows institutions to eliminate unnecessary features and focus on exactly what they need.

- b. Privacy and Security Concerns: The growing number of connected IoE devices and sensors makes networks more vulnerable to cyber-attacks, causing reasonable consumer concerns about a possible leak of data. Threats like data theft, “phishing” activity, man-in-the-middle attacks, ransomware, and so on are not excluded. Such situations can have an extremely negative impact on the reputation of the educational institution and create serious problems for students.

Institutions should not ignore following all security policies to protect data and do their best to raise awareness among students and staff about digital hygiene. Don't save on protective measures and contingency plans for the event of cyber threats. Use only trusted solution providers who apply only best practices and the latest security technologies to their protocol.

- c. Adaptability to Change: Technology, as the great growling engine of change, does not merely add something; it changes everything. Of course, not everybody wants to learn new systems, build their skills, or adapt to a new way of working. A great percentage of staff and students are resistant to this change (IoE) because what they did previously worked well for them. They may be

hesitant about the change. Such resistance may take a number of forms—persistent reduction in output, chronic quarrels, sullen hostility, wildcat or slowdown strikes, and, of course, the expression of a lot of pseudological reasons why the change will not work.

To alleviate staff and student concerns around change, institutions may need to take a multi-pronged approach to overcome their resistance. This approach is listed as: engaging those who are opposed to change, offering an explanation for why change is necessary, implementing change in several stages, and communicating change effectively.

## VI. IMPLICATIONS OF IOE IMPLEMENTATION IN TERTIARY INSTITUTIONS

It is impressive that IoE implementation in tertiary institutions will revolutionize academic excellence and administrative efficiency in the following ways:

- i. Increasing staff and student engagement and interest: There will be changes for the better in staff progress, and students positively rate the experience with technology as effective and interesting.
- ii. A customized approach to learning: IoT sensors in tertiary institutions will help educators plan lessons based on the needs of every student, while robotic solutions enable the personalization of curriculum content and pace based on how students respond to questions or solve test tasks. Students with special needs learn more effectively with the use of connected devices and aids.
- iii. Automating processes and decreasing bureaucracy: an IoT solution for the education sector gives teachers the opportunity to do more creative work and constantly improve their skills instead of wasting time on bureaucracy and routine. Smart biometric cards help automate attendance statistics, control the location of students in a school or college building, and inform parents about student progress and highlights in the educational process.

iv. Resource usage optimization: IoE facilitates reduced operating costs and enhanced energy efficiency in tertiary institutions. Most commonly, the largest expenses of tertiary institutions are for energy and other resources. The advantage of IoT devices is that they can turn off lights, water, an air conditioner, or a projector if they are forgotten to be switched off.

v. Safety of students, teachers, and classrooms: The use of IoE solutions in education makes the learning environment more secure due to the adoption of smart cameras, smart ID cards, smart access control, leakage, and/or smoke sensors.

As it emerges from this paper, the adoption of the IoE in tertiary institutions has a positive influence on excellence in teaching and learning, efficiency in bureaucracy and managerial activities, and maximizing energy efficiency by minimizing losses, energy consumption, and its effect on climate change. To guarantee this, the necessary infrastructure, such as a steady electric power supply, backbone networks, high internet speed, and penetration, must be in place.

## VII. CONCLUSION

There is enormous value in connecting the unconnected with smart networks across tertiary institutions. This paper demonstrates the IoE's implementation in academics and its integration in administration as an emerging tool for revolutionizing education in tertiary institutions. It also established the potential impact of making education more relevant, engaging and motivating learners, and enabling a faster time to mastery.

However, to realize the benefits of connecting people, teaching, learning, processes, data, and things, a reliable, steady electric power supply and continuous access must be guaranteed. Additionally, for IoE to be accepted, both policymakers and institutions must be well-prepared not only to exploit but also to understand potential risks.

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