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Review Manuscripts

Smart Grid in Tanzania: Research Opportunities

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ABSTRACT

During the past five years, the Government of Tanzania has reinvigorated its power generation capacity significantly to ensure smooth execution of its industrialization agenda and cope with the fourth industrial revolution. To ensure reliable availability of power to sustain its growing economy, Tanzania embarked on a deliberated measure to forge an energy mix. This deliberate measure encompasses the use of renewable energy technologies such as wind, solar, biomass, wastes, and micro hydro; natural gas; and other energy sources which are locally available including coal and geothermal. To effectively and efficiently manage such a growing power system and make electricity accessible to all for higher levels of industrial investment and services, the adoption of the smart grid technologies becomes inevitable. This article, tried to unveil possible potential research areas in which scholars, through academia-industry collaborations, can dwell to ensure that the Tanzania smart grid concept is seamlessly realized and maintained, with the expected efficacy. Through literature review, nine research areas have been identified as potential areas relevant to the Tanzania smart grid development.

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INTRODUCTION

The invention of electricity and development of the electrical power grid could be demonstrated as one of the greatest engineering achievements of the 20th century. However, the power industry is currently facing new challenges of sustainability, energy security and reliability (Fang et al. 2012). Over the past decade, technological developments around the globe have affected the way electricity is generated, transmitted and distributed. Developed economies have managed to install intelligent management systems onto their grids with continuous improvements, while developing countries are still at the infancy stages in automating their grids. It has been observed that in the traditional grid there are relatively few power generation or injection points and millions of points of power consumption (Jakaria et al. 2021). The rapid development of distributed and renewable generation, has made the current grid to consist of numerous points of power injection as well as millions of points of consumption (Bazila et al. 2022). To manage the electric power grid of such an increasing number of alternating electricity sources, vast transmission and distribution networks, a smarter automation system is imperative. To facilitate the electric grid automation, Information and Communication Technology (ICT) has been adopted to introduce intelligence at all levels of the electricity supply. Hence, ensuring effective and efficient management of the electrical power network.

The dynamic nature of human needs has made it challenging to find balance between the supply and demand for electricity. The peak load management scheme, for example, tries to bring the balance between the generated electricity and demand through control of loads. Schemes like demand response have been proposed to supplement the supply gap which utilities face during the peak consumption hours. The scheme allows for lower electricity cost at non-peak consumption hours for keeping the supply and demand of electrical power in balance (Maziku et al. 2021). Beyond these factors, the world has been advocating for renewable and green power sources to protect the environment and curb climate change. However, renewable energy is inherently variable, forcing the transition to intelligent power grids that can accommodate all these issues.

It should be noted that each global driver for intelligent grids or smart grids applies to Tanzania, but Tanzania has also some additional drivers in the short and long terms. The electrical power system in Tanzania has roughly doubled in the last ten years. With 1,602 MW of installed capacity with utility as of July 2020 (Ministry-of-energy 2020), the Tanzanian power system is growing at a rate of 15% annually, needing sustainable management strategies to support the economy growth. The per capita electricity consumption is expected to increase from 377 kWh in 2020/21 to 490 kWh by 2025/26 (Ministry-of-energy 2020). This has resulted from rural electrification projections through the Rural Energy Agency (REA), extended distribution network, formation of new businesses, revival of dormant industries, mushrooming of new power-hungry buildings and high urbanization rate. The energy demand in Tanzania by 2040 is projected to be as high as 40 GW with a potential share of renewable energy of 6 GW available for exploitation till 2040 (URT 2021). This dictates the urgency to build a sustainable power system at a fast pace for the next several decades. Tanzania is also pursuing aggressive hydro and renewable generation projects. The targeted generation capacity by 2025 is 5,760 MW to be contributed mainly by renewable energy, the completion of the Julius Nyerere hydropower plant and extension of Kinyerezi gas-fired plants (URT 2021). A power system of such a size with an appreciable share of hydro, gas and renewable energy requires intelligent systems to effectively manage it and guarantee its reliability and stability. Tanzanian Government, in the third phase of five-year development plan 2021-2025, intends to automate its electricity transmission and distribution systems in order to secure and maintain reliable electricity infrastructure that can meet the growing demands.

In the Tanzanian electrical power system, technical and non-technical losses in the transmission distribution networks are still high. The Government through the utility company has made loss reduction a top priority (Mbembati et al. 2021). Installation of intelligent grid automation systems will monitor, measure and control in real-time the power flows so that faults are identified in time and appropriate technical and managerial measures are taken to curb the losses. Currently, the national utility company is upgrading the infrastructure to Advanced Metering Infrastructure (AMI). AMI, a smart grid subsystem at the consumer side, automates reading and the billing of power consumption (Le et al. 2016). The AMI uses a two-way communication system between smart meters and the utility center, passing through an aggregator or gateway, to relay the consumption data and other control information making the electrical grid smart. Electrical power monitoring systems play an important role in the evolution of the intelligent grid. The smart metering implementation is intended for all urban and rural areas and the AMI can be effectively leveraged to transform utility to smart grids with low incremental costs.

In realizing the importance of transforming the electric grid into smart grid in the Tanzanian power sector, this paper reviewed and identified potential thematic areas to sustain the smart grid operations. Using reputed databases, a number of potential research areas were identified for the stakeholders to dwell on to enhance the efficacy of smart grids through intensive state-of-the-art research.

Smart grid concept

A smart grid is an intelligent electrical grid with automation and ICT systems that can in real time or near real-time monitor power flows from generation to consumption points and have the capability to control the supply and demand. The increased visibility, flexibility, predictability, and even control of supply and demand enable the utility companies to better integrate other sources of electricity generation and also reduce electricity costs during peak consuming hours (Jain and Mishra 2017).

The adoption of smart grid concepts and technologies comes with a challenge to prepare for the future of complex distribution networks, changing customer behavior, alternative energy sources, technology advancement and diversified economies. To cope with these trends, the energy industry should attract the integration of renewable energy sources, use of electric vehicles, encourage innovative energy efficient schemes and development of cities or smart neighborhoods.

To accomplish the mission, several smart grid architecture models are reported, which follow a multilayered structure. The authors in (Qarabsh et al. 2020), define three main layers of smart grid: power systems, communications and applications layers (Figure 1). The power system is responsible for generating and delivering electrical energy to the users similar to the traditional grid. The communication layer is interconnecting all the system components and the applications layer is responsible for processing information, monitoring and control, and managing applications such as demand response, automatic meter reading and detection of fraud or misuse (Maziku et al. 2021).

Literature suggests that the application and communication layers can be combined to form information infrastructure. The information infrastructure could also be analyzed into ICT, control and management layers. These parts form the AMI that is divided into automated meter reading, automatic meter management and network management. The advanced and sophisticated communication systems in smart grid operate either in wired or wireless media. The wired communication technologies include powerline, digital subscriber lines, fiber optics or ethernet. On the other hand, wireless communication includes Worldwide interoperability for Microwave access (WiMax), public cellular networks, Wireless Metropolitan Area Networks (Standards Coordinating Committee et al. 2030), satellite based, Wireless Personal Area Network (WPAN), IEEE 802.15 technologies and Wireless Local Area Networks (WLAN) (Qarabsh et al. 2020).

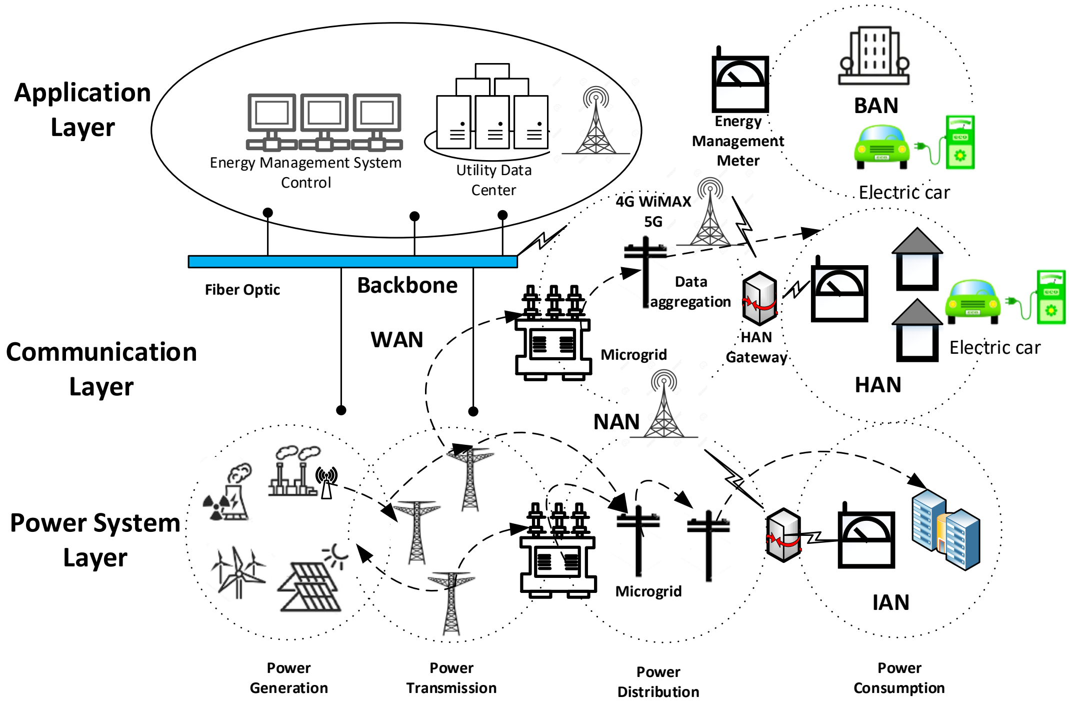

Figure 1: Smart Grid Architecture.

The IEEE 2030 based technology standard is intended for communication architecture in smart grid where there is a hierarchical arrangement of services, infrastructure and applications (Ghoneim 2018). The goal has been to create a consensus on the existing number of technologies and accommodate them into some limited ICT infrastructures. Therefore, the Smart grid communication systems infrastructure can be described with three sub networked hierarchies: The Building Area Networks (BAN), Home Area Network (HAN), and Industrial Area Networks (IAN). The BAN, HAN and IAN networks are used in the areas where electrical consumption is done (Standards Coordinating Committee et al. 2030). In the consumption level, the consumers also form Neighborhood Area Network (NAN) and Field Area Network (FAN). The NAN and FAN comprises the local area network (LAN) that is used in the distribution part of the electrical power network. The last and widest network, Wide Area Network (WAN), provides communication in several kilometers and involves other types of LANs, Management Systems (DMSs) and Virtual Private Networks (VPNs) for transmission network operations (Kimambo et al. 2022). Since the BAN is a subset of HAN, and IAN a subset of FAN, the information infrastructure could be summarized into HAN, FAN and WAN as shown in Figure 2. To reap the full benefits of smart grid, it depends on the operation of several nodes like smart transformers, intelligent electronic devices, phasor measurement units, smart power converters, and remote terminal units, installed with sensors to feed the required measured and monitoring data to the utility control center. Thus, the entire electrical power network is converted to an intelligent, interactive, flexible, versatile, self-healing, adaptive, secure, predictive and self-healing system. The smart grid system also provides resilient operations against cyber-attacks by predicting possible malicious network penetrations, induced faults and failures in the grid, and rapidly reacts to overcome faults occurring at any level (Maziku et al. 2021).

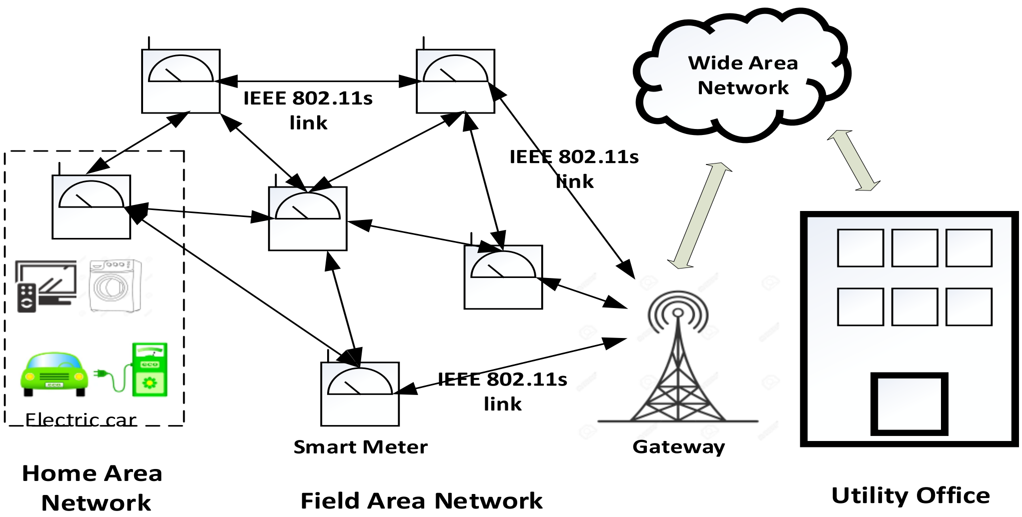

Figure 2: Smart Grid Information Architecture (Kimambo et al. 2022).

Equivalence these infrastructures enable smart grid to provide real-time energy consumption information to consumers which helps to control the costs and improve their performances. Customers can respond to the utility and hence minimize the period of surpluses and outages. This revolution in the management of the power grid brings several advantages to the utility, consumers and the Government. Smart grid facilitates the integration of renewable and distributed sources into the grid. It provides a platform for the development and deployment of smart technologies and other useful applications like demand response, demand-side resources, and energy-efficiency resources (Mbembati et al. 2021).

The information infrastructure supports the Supervisory Control and Data Acquisition systems (SCADA) application for gathering of data in real-time or near real-time from remote locations in order to control electrical equipment and conditions (Jakaria et al. 2021). The geographic information systems (GIS) is used for mapping of electrical power network assets and consumers. Also, there are outage management systems, forecasting, wide area measurement mobile crew management systems and control systems, dispatch and settlement tools. These applications form part of the advanced Smart grid system capable of managing the network for most of the contingencies (Hasan and Mouftah 2019). It should be noted, however, that these applications are developed depending on the needs of a particular utility. Therefore, they are open for research and improvement.

The smart grid could enable the realization of the 4th industrial revolution, Smart Grid Industry 4.0 (SGI 4.0) (Qarabsh et al. 2020). The concept of industry 4.0 encompasses the entire life cycle of the product. The automation of this life cycle can be achieved through ICT technologies such as Internet of Things (IoT), cloud computing, machine learning and cyber physical security (Gunduz and Das 2020). SGI 4.0 could keep track of all the important metrics about the transmission and distribution of electricity in the grid. Data provided by smart devices, transformers and consumption statistics can be used via machine learning or artificial intelligence to provide advanced decisions. The SGI 4.0, has received worldwide attention as of recent and there are extensive discussions from practitioners, researchers and manufacturers on using SGI 4.0 to improve grid operations. SGI 4.0 enhances the manufacturing process, enables rapid growth of industry and provides supply and demand integration.

The Internet of Things (IoT), big data analytics and automation are the leading research avenues in smart grid.

Industry-Academia Collaboration in Tanzania

During the 1990s, industrialists complained about the lack of practically oriented engineers who can be readily adapted into the working environment and solve real-life challenges. The industry witnessed a decline in graduates' design-skills, which is a fundamental component in the problem-solving capability (Ibwe et al. 2018). So, the debate has been on how to bring education closer to industrial needs and meet the expectations of both parties. The collaboration of academia and industry promotes innovation and technology transfer, and ensures that graduates have the skills and knowledge required to effectively contribute to the workforce.

In this paper, the academia-industry collaboration is presented on the electrical power system context in Tanzania. The authors in (Ibwe et al. 2018) presented the impact of involving the industry through Challenge Based Learning (CBL) in Tanzania. The CBL is the learning methodology where academia collaborates with industry to solve real-life challenges. The role of CBL in strengthening the academia-industry collaboration has gained momentum in recent years and is widely recognized as an important growth factor for education, research and innovation(Mas 2019). The education, research and innovation form the Triple helix model, which is a revolution in education based on the cooperation of industry, government and higher learning institutions. In this model, academia focuses on establishing institutional interface structures including industry liaison/technology transfer offices, business and technology incubators, and fostering entrepreneurialism through various policies and incentives (Liu et al. 2021). In engineering education, the triple helix model is realized in a number of different approaches including problem-based learning, living labs and active learning methods (Kalinga et al. 2018).

The linkages between academia, industry and government involves student industrial attachment, staff exchanges and placements to more complex partnerships such as business and technology incubator and industry-sponsored projects. Other methods of partnership include training and curriculum development, research and development and consultancy. Likewise, industries may commission a specific research project, or sponsor a university chair in an area of interest (Nilsson and Norell Bergendahl 2020). Through CBL, which is a multidisciplinary methodological approach towards problem solving, the authors in (Ibwe et al. 2018) reveal the step processes taken to engage the utility company in challenge identification, team formation and execution of proposed solutions. Multidisciplinary teams in electrical, control, computer and electronics engineering were created and divided into different areas of specializations. The smart power system was then summarized to consist of sensor networks, communication technologies, gateways and protocols, database management, supervisory control and data acquisition (SCADA), Geographical Information System (GIS) and front-end applications.

The authors in (Kalinga et al. 2018) identified the main challenge in the Tanzania power system as fault management accounting for both technical and non-technical losses. To enable the effective and efficient management of the electrical power system, different schemes are proposed. These schemes have resulted in research thematic areas like regulations, safety, network communication, data management, tariff, demand response, energy storage, interoperability and distribution grid management components discussed in subsequent section.

Thematic Research Areas to Enable Smart Grid

There has been a global rising demand for electrical power, which stimulated the grids' complexities by rising requirements for greater reliability, efficiency, security and environmental and sustainability concerns. To effectively achieve the above features, researchers have been working diligently to improve the smartness of the power grid. Besides, the recent research advances in the field suggest that grids and network systems should not only be concerned in power transmission and distribution but also in the generation of clean and sustainable energy in order to reduce greenhouse gasses and carbon footprint and hence observe climate change. This paper reviewed related literature from reputable databases to determine current research themes. The vastness of the smart grid research areas was reduced to 50 related research articles with academia-industry origins. In analyzing research opportunities in smart grid technologies emanated from academic-industry-government linkages, Tanzania was chosen as a case study.

The involvement of end users and third-party service providers will likely change the smart grid ecosystem with technologies and schemes that will enable sustainable management of the grid. It is therefore imperative that research opportunities in smart grid technologies will open up new ventures of collaboration between industry and academia for globally accepted solutions. In this section, thematic research areas in smart grid technologies are presented resulting from literature analysis.

Demand and energy management system

For a reliable grid, all essential components from generation to energy consumption should be well orchestrated by using intelligent computer software. Energy management system is liable to provide a platform for all stakeholders of the power grid to work together to form a modern, reliable and efficient grid system (Dileep 2020, Majeed Butt et al. 2021, Talaat et al. 2020) . In this scenario, technologies like advanced metering infrastructure (AMI), grid communication networks and cybersecurity enables self-decision capabilities in the grid which make the energy management system more realistic for the smart grid(Abdelaziz et al. 2020, Kotsiopoulos et al. 2021). The focus is to maximize reliability/resilience/stability, and reduce cost which is not trivial. Others are demand management for climate change mitigation and climate change adaptation (Abrahamsen et al. 2021, Dileep 2020).

Communications and networks to enable the smart grid

Upgrading the existing energy infrastructure to a smart grid requires provision of integrated communication solutions to ensure the interoperability of business processes and reduce the risk of devaluation of traditional systems already in use. Key tasks entail the integration, cooperation, and information interchange among the interconnected elements of the power grid. Communication improvement enablers in existing power networks include IoE for energy systems, Machine to Machine (M2M) and IoT (Alhasnawi et al. 2021).

Internet of Things (IoT)

With the development of smart grid and its components, there was a need to interact with these components in an efficient, smart and reliable way, Internet of Things (IoT). The IoT has fulfilled all these characteristics taking the smart grid into the new era. However, there exist some serious security concerns challenging this promising technology including impersonation, overdoing, data tampering, privacy issue, authorization and cyberattacks, which are among the topical issues in the current smart grid related research (Bekara 2014, Ghasempour 2019, Gunduz and Das 2020, Majeed Butt et al. 2021). The IoT connectivity enhances consumer's experience and efficiency and hence fosters a flexible and easy interaction with the power grid so that it lowers associated costs by diagnostics and neighborhood-wide meter reading ability(Bekara 2014, Ghasempour 2019, Gunduz and Das 2020).

Big data management

When a smart grid is reliably and efficiently working, a huge data volume is collected from power generation, transmission, transformation and utilization to execute all decisions and automations in the grid(Majeed Butt et al. 2021). The gathered data, from generation to utilization, can be used in forecasting and recognizing the power utilization patterns, which are vital in realizing smart energy management systems. Despite the notable achievements on the big data research, there still open problems, which are the current focus of many researchers lately, in data and outlier mining and governance, big data processing analytics, data integration and data sharing and most prominently security and privacy (Espinosa et al. 2019, Kotsiopoulos et al. 2021, Majeed Butt et al. 2021, Massaoudi et al. 2021, Wilcox et al. 2019).

Deep learning-based prediction

A number of milestones have been achieved in using Machine Learning (ML) techniques for various sub-areas in the SG. However, shallow neural networks and sample ML models pose impinging challenges that make them rarely employed especially for complex problems in Electric Power Systems (EPS) (Kotsiopoulos et al. 2021, Maamar and Benahmed 2019, Massaoudi et al. 2021, Yin et al. 2020). Broadly, the challenges lie in two facts: simple ML algorithms are ineffective for high-dimensional data representations with unreasonable complexities; the accuracy of simple ML models cannot be improved with large data volumes. To address these challenges, the learning paradigm shifts to Deep Learning (DL) as the most dazzling flagship of ML for using Big Data abundance with hierarchical feature extraction, high efficiency, and timely manner. Deep Neural Networks (DNNs) have quickly ascended to the spotlight due its improved computing performance and data capacity. The DL paradigm has achieved notable success due to its strong potential to represent the associated learning process. The performance of DL techniques is solidified based on multiple processing units to learn feature representations with layers of abstraction. Due to its wide success, there is a notable proliferation in using the DL for the EPSs to exhibit complex correlations from heterogeneous data with different data formats. Notably, the complexity of the SG has strengthened the demand of the DL to make use of the big data emanating from smart meters and Internet of Things (IoT) devices. The SG community therefore, has been encouraged to apply DL methods to tackle variety of miscellaneous and critical problems including forecast and prediction, fault detection and diagnosis, and cybersecurity (Kotsiopoulos et al. 2021, Maamar and Benahmed 2019, Massaoudi et al. 2021).

GIS sources mapping, transmission and distribution networks

Geographic Information Systems (GIS) and Remote Sensing (RS) techniques play a vital role in assessing and monitoring Renewable Energy Sources (RESs) potential which is critical in planning their high-penetration in the energy systems and in the grid network and its facilities. The main focus shall be to develop an advanced power system information infrastructure and digital framework using ICT mediated GIS. The GIS applications in the power system are envisioned to facilitate planning, designing, development, operation, maintenance, management, and future expansion (Nastasi and Nezhad 2022, Zalhaf et al. 2022).

Hybrid microgrids and local power generation

The global energy requirement has increased rapidly in the past two decades raising concerns over adequacy and security. In such a case, energy resources become instrumental in the global economy and geopolitics of clean energy to ensure sustainable development. Energy resources management includes strategic control and storage of the energy supply. Microgrids, particularly hybrid microgrids, contribute another layer to the apparent advantages of renewable sources by enhancing performance and mitigating energy losses. Current researches in hybrid microgrid includes robust control methods, inverter topologies, storage designs, load supervision and optimization strategies to enhance microgrids' performance underlining the scope of the future trends in the areas applicable to energy resource planning (Barik et al. 2022, Hajiakbari Fini and Hamedani Golshan 2018, Kerdphol et al. 2019, Yang et al. 2019).

Green Communications in Smart Grid

As the vision of smart cities is to become a reality, sensors and embedded systems and platforms deployed increase rapidly. Besides, communication requirements of such systems and subsystems in smart cities similarly increase. The energy requirements, for providing connectivity to a number of new devices, and tons of message exchanges would contribute considerably towards the greenhouse gas emissions. Thus, for sustainable smart cities the green communication technologies and solutions become inevitable.

In smart cities setup, green communication is challenging due to massive machine type devices; a diverse range of applications; different traffic requirements and deployment scenarios; a wide range of used equipment; numerous energy efficiency trade-offs; and heterogeneous communication architectures. To overcome some of these challenges, researchers are working on following related areas including but not limited to energy efficiency mechanisms and green communication; cognitive radio and TVWS in smart city applications; use of 5G and massive MIMO technologies; energy harvesting, wireless power transfer; physical layer security; and energy-efficient high definition video streaming (Dao and Kim 2018, Khalil et al. 2021, Khan et al. 2020, Zahid et al. 2019).

Smart grids with electric vehicles

The leading environmental concerns, including pollution and climate changes, are due to vehicle emissions. The use of electrical vehicles (EVs) was found to alleviate the problem. However, when interacting with the grid, EVs pose several challenges on the infrastructure, communication and control systems. Besides, the domestic charging of EVs tends to stress the electric distribution network. However, EVs can significantly improve the quality of power and performance of the grid if the charging process is well planned and the EVs are well integrated to the grid (Majeed Butt et al. 2021, Mwasilu et al. 2014).

Since the SG comprises advanced technologies in communication, smart meters and control, it has a potential to exploit the EVs as flexible energy sources, in which the smart meters play an important role in addressing the challenges faced by the grid associated with the EVs. In vehicle to grid (V2G) technology, one can predict the dynamics of the power system and the current research dwells on the charging and discharging of EVs which is essential to grid technology (Dileep 2020, Majeed Butt et al. 2021, Mwasilu et al. 2014).

Table 1 summarizes the underlined research areas and their possible corresponding research questions.

Table 1: Summary of research areas with their possible research questions

No	Research area	Possible research questions
1.	Demand and Energy management system	a) How can the proprietary prepaid and post-paid electrical power meters allow remote monitoring and control by a remote server to minimise non-technical and revenue losses and introduce consumption control by consumer? b) How can cost effective smart meters be used to build a smart grid ecosystem in Tanzania?
2.	Communications and Networks to Enable the Smart Grid	a) How can reliable and affordable internet connectivity be assured to sustain smart grid network operations for different technologies, protocols, controls and link power? b) What are the traffic models/trends/technologies that are most suitable for Tanzania smart grid applications?
3.	Internet of Things (IoT)	a) How can signal processing and coding techniques for energy related sensor information from the perspective of IoT framework be innovated/adapted to suit local context applications in smart grids? b) How can smart grid system security be enhanced to guarantee data integrity, availability and privacy?
4.	Big data management	a) How can an IoT-based framework support efficient data mining in a smart grid? b) How can database queries be efficiently resolved in real-time big data analysis in smart grid applications?
5.	Deep Learning-based prediction	a) How can DL based algorithms be applied to enhance fault detection, diagnosis and prediction in a smart grid? b) How can DL based algorithms be casted to enhance security of the smart grid?
6.	GIS Source Mapping, Transmission and Distribution Networks	a) How can GIS be utilised to improve efficiency and effectiveness of the electrical power grid management? b) How can GIS mapping of electrical power sources improve reliability and responsiveness to consumers' queries?
7.	Hybrid Microgrids and Local Power Generation	a) How can networked microgrids be efficiently managed in a large number of isolated grids and sources to improve reliability of power supply in rural communities? b) How can scheduling and coordination algorithms be improved to facilitate local autonomous control of household appliances and power systems?
8.	Green communications in smart grid	a) How best can potential ambient energies be harvested to drive low-power appliances? b) How can the TVWS be modelled to support cost-effective smart city applications?

No	Research area	Possible research questions
9.	Smart grids with electric vehicles	a) How can electric vehicles be exploited as alternative flexible energy sources? b) How can the electric vehicles be efficiently charged and discharged?

Relevance of the Research Areas for the Country's Development Challenges

Impact of inefficient monitoring and control systems

The charge rate for electricity in Tanzania, as perceived by domestic and industrial users, is relatively high which tends to motivate consumers to cheat and collude with dishonest employees. This makes major, medium and small consumers not paying bills reflecting their actual electrical power consumptions. Therefore, the utility company unjustly raises charging rates to cover the losses. This is easy because the electrical power grid is manually operated particularly in the SDN; hence inefficient management and operation of the network. Also, customers complain of poor quality and unreliable electrical power supply. This has to change considering exponential expansion of the network by introducing smart grid. Moreover, the manual system is costly and time consuming.

Smart monitoring and control systems

The growing power system (generation, consumers and network) with an increasing renewable energy and islanded systems, require smarter management systems to ensure stability and reliability to all its customers. Intelligent systems can facilitate energy-saving behavior by customers. It is important to monitor the entire grid system from generation to distribution and control electrical loads automatically, record usage and analyze it for consumers to be able to manage and have complete control on their consumption.

CONCLUSION AND RECOMMENDATIONS

Responding to the increased demand of the electric power in Tanzania due to the industrialization and urbanization campaigns, the country would need to instill new electric power sources and improve the efficacy and productivity of the existing power grid. To realize the smart grid concept, academia has a potential role to mold and equip technical staff to support the agenda by conducting cutting-edge related research and offering a series of relevant professional training. This paper tried to unveil the possible research opportunities in the Tanzania electric power grid towards its digitization process. Through the academia-industry collaborations, the country's smart grid can seamlessly be realized to reduce power losses and hence improve the grid performance and automations. To ensure the sustainability of the smart grid operations, the academia can offer regular training and professional courses to the utility personnel and stakeholders.

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