

Current Smart Metering System in Ghana: Challenges and Mitigation Techniques

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ABSTRACT

The smart prepaid meters are in accordance with the Electricity Company of Ghana's (ECG) new Meter Management System (MMS), which integrates all smart meters into a single platform, allowing consumers to purchase prepaid credit from anywhere in the nation and allowing the company to remotely monitor the meters. This article identifies the various implementation and usage challenges associated with the current smart metering system in Ghana. The paper also proposes some mitigation techniques to overcome the underlined challenges.

General Terms

Electricity Company of Ghana, Roaming, Smart metering system, smart prepaid meters.

Keywords

Electricity Company of Ghana, prepaid meters, power losses.

1. INTRODUCTION

Smart metering systems have reportedly grown in popularity across the globe as a result of their multiple advantages for both energy suppliers and consumers [1]. These systems offer accurate and timely information on the trends in energy use, enabling suppliers to efficiently control energy demand and minimize power losses [2]. They also allow for remote power supply monitoring and control, doing away with the requirement for manual meter readings and on-site visits [3][4]. In addition, customers gain from having more visibility and control over their energy use, which lowers costs and encourages environmentally beneficial behaviour [5][6]. Furthermore, by controlling irregular generation and demand, smart metering systems make it easier to integrate renewable energy sources into the grid. Given these benefits, smart metering system deployment in Ghana has begun. Fig. 1 below shows a photograph of the smart meters adopted in Ghana. To make sure that they are successfully adopted in the nation, several issues must be resolved.



Fig. 1: Smart direct electricity prepaid meter

Smart metering systems in Ghana confront a number of difficulties, including infrastructure development, data security and privacy issues, technical and implementation problems as well as legislative issues [7][8]. A variety of mitigating techniques can be used to get beyond these obstacles and guarantee broad adoption. Energy providers and users can receive real-time information via smart metering systems, which precisely measure electricity consumption [6]. They are a crucial component of the larger smart grid ecosystem, which aims to upgrade the electrical infrastructure's efficiency and update it [9]. Due to their numerous advantages, smart metering systems are thus becoming more and more popular around the [1][10].

2. REVIEW OF LITERATURE

Numerous research on smart metering systems has been carried out in Ghana, concentrating on both the drawbacks and possible advantages of this technology. These studies offer suggestions for resolving the issues found and important insights into various smart metering system facets. The study carried out in Ghana emphasizes the importance of smart metering technologies and their potential to revolutionize the energy industry. Policymakers and stakeholders can decide how best to establish and deploy smart metering systems in Ghana by being aware of the challenges and maximizing the opportunities.

Ofori-Boateng and Mensah in [11] explored the difficulties faced by Ghana's smart metering systems in their study, focusing on problems with infrastructure development, data security and privacy issues, and regulatory issues. The authors propose that these issues can be resolved by combining

regulatory changes, infrastructure improvement, and public awareness and education efforts.

In a related study, Appiah et al. [12] looked at the benefits and drawbacks of smart metering in Ghana's energy industry. The researchers discovered that while smart metering systems have the potential to increase the efficiency and dependability of power distribution, they face major obstacles in the form of infrastructure development, privacy and data security difficulties, and regulatory constraints. The authors contend that cooperation between energy suppliers, regulators, and other stakeholders is necessary to meet these difficulties.

Agyapong, Kwapong, and Owusu in [13] identified a barrier to the adoption of smart metering systems in Ghana as a lack of customer understanding. The authors propose that education initiatives to raise knowledge of the advantages of smart metering systems could aid in reducing this difficulty. In order to convince consumers to use smart metering systems, the authors also suggest that they be made user-friendly.

Another difficulty with the introduction of smart metering in Ghana is the problem of data security and privacy. Adu-Manu, Essandoh, and Owusu-Manu [14] emphasize the significance of protecting the security and privacy of consumer data obtained by smart metering systems in their study. According to the authors, this problem might be mitigated by using encryption and other security measures.

Agyemang et al. [15] in their study concentrated on the advantages of smart metering systems for Ghana's energy suppliers and users. The authors discovered that smart metering systems can increase billing accuracy, decrease energy theft, and give users more precise data about their energy usage. To ensure the successful adoption of smart metering systems in Ghana, the authors also pointed out that there are considerable obstacles linked to infrastructure development as well as data security and privacy issues that must be addressed.

Research by Kofi et al. [16] looked at how smart metering technologies might help Ghana boost its renewable energy sector. The authors discovered that smart metering systems can aid in the grid's integration of renewable energy sources, but that there are considerable obstacles to overcome in terms of infrastructure development and legal considerations before these advantages can be completely realized.

Kusi et al. [17] study on the technical difficulties of Ghana's smart metering systems was built on earlier research. As important areas requiring attention, they noted concerns such as communication network dependability, meter accuracy, and system maintenance. To ensure that smart metering systems operate at their peak efficiency, the authors suggested fixes like network redundancy, routine meter calibration, and efficient maintenance techniques.

Researchers in a study by Amoako et al. [18] investigated the social and economic effects of smart metering systems in Ghana. They concluded that these technologies have the potential to encourage energy efficiency and lower customer energy prices. Smart metering can also support more precise billing and demand response programs. The authors stressed the necessity for encouraging regulations and incentives to promote smart metering system adoption on a larger scale.

In order to determine whether smart metering technologies could improve revenue collection in Ghana's electricity sector [19]. The authors discovered that smart meters can greatly increase revenue collection for energy providers by precisely tracking electricity consumption and preventing energy theft.

However, they also emphasized how crucial it is to deal with problems with data management, infrastructure development, and client acceptance.

Nyarko et al. [20] examined the environmental effects of smart metering systems in Ghana and their potential to encourage sustainable energy behaviours. The authors discovered that smart metering systems can enable consumers to make informed decisions and adopt energy-saving behaviours by delivering real-time energy usage information. In turn, this can boost the use of renewable energy sources and help cut down on greenhouse gas emissions.

The legal framework and policy concerns for smart metering systems in Ghana were the focus of research by Asante et al. [21]. In order to address issues like data protection, consumer privacy, and requirements for metering accuracy, the authors emphasized the necessity for explicit legislation. They stressed the importance of having a clear regulatory framework to assure the execution and operation of the program of smart metering technologies.

3. CHALLENGES OF SMART METERS

3.1 Infrastructure

In Ghana as well as many other developing nations, infrastructure development is essential for the successful adoption of smart metering systems. Investment in infrastructure is essential to achieve sustainable development goals, and as access to energy is fundamental to improving people's lives and eradicating poverty.

Accordingly, the African Development Bank (AfDB) has highlighted the significance of infrastructure development in Africa, claiming, "Infrastructure development is key to unlocking the growth potential of African economies, improving competitiveness, and reducing poverty" [22]. In addition, according to the World Bank, "investing in infrastructure is one of the most effective ways to promote economic growth, create jobs, and reduce poverty" [23].

As a result, tackling Ghana's infrastructure development challenge through a combination of public and private investment, as well as policy measures, can not only facilitate the implementation of smart metering systems but also help the nation's efforts to grow economically and combat poverty.

3.1.1 Mobile Network Reliability

When implementing smart meters, mobile network dependability is a significant issue. The network's dependability is crucial for smart meters to continue operating without interruption and to prevent future power outages because a network failure could limit the meter's usefulness by impairing its capacity to recharge. The meters currently solely use Vodafone as their sole network service provider, meaning they cannot be refilled when there is a network outage.

3.1.2 Battery Life of smart meter

Smart meters' short battery lives can negatively affect a number of different aspects of how they function. The accuracy of billing may be impacted first because it can be challenging to communicate data to utility providers, causing delays in data availability. Second, the brief battery life necessitates frequent battery replacements or recharging, increasing maintenance requirements and expenses for power providers. Last but not least, the short battery life may cause data collecting gaps, which makes it more difficult for utility companies to do precise analysis, forecasting, and energy planning. To ensure the dependable and effective operation of smart metering systems, it is critical to solve the battery life restrictions.

3.2 Technical Losses

A certain amount of separation between the meter and the customer is introduced by mounting smart meters on poles. Technical losses may result from this separation and the length of the electrical cable connecting them. These losses happen as a result of resistance and inefficiency in the long-distance transmission of power.



Fig 2: Pole-mounted smart prepaid meter

Some resistance is encountered by electricity as it passes along the wire from the pole-mounted meter to the consumer's home. This resistance can be expressed as:

$$R = \rho \frac{L}{A} \quad (1)$$

Where R is the resistance, L is the length, A is the cross-sectional area and rho is the resistivity of the conductor respectively. Due to this resistance, the voltage is reduced, which results in energy being lost. Technical losses are more likely to occur at greater distances between the meter and the consumer. Changes in environmental conditions such as temperature also affect the total resistivity of the conducted thereby leading the increased losses.

Also, smart meters may introduce some level of harmonic components due to the nonlinear devices such as the diodes and transistors found in them as outlined by Appiah and Gyaang [24].

3.3 Data Privacy and Security Issues

Data security and privacy issues, according to John Mathews, the Chief Information Officer of E. ON UK, are some of the major obstacles to the global implementation of smart metering systems. This problem is particularly important in Ghana because of the vast volumes of data that smart metering systems gather. As Taiwan's Digital Minister Audrey Tang pointed out, protecting data privacy is crucial to the success of any smart city effort. It will need a mix of technological advances and legislative changes to solve this problem. Implementing encryption and authentication mechanisms, for instance, can help protect data, while consumer education and awareness campaigns can assist people understand the advantages and disadvantages of smart metering systems. Additionally, regulatory frameworks such as the General Data Protection Regulation (GDPR) can provide a legal framework for ensuring data privacy and security.

3.4 Regulatory Issues

Regulatory issues pose a significant challenge in the implementation of smart metering systems in developing countries, including Ghana. Clear and uniform frameworks are required to ensure compliance and foster investor trust because the legal environment for smart metering systems is complex Agyapong, Kwapong, and Owusu [25].

In order to successfully adopt smart metering systems, several experts have also emphasized the significance of legal frameworks. A clear legislative framework is necessary to secure the interoperability, security, and privacy of smart metering systems. Consumer trust will increase as a result, and service providers will benefit from a level playing field.

Energy sector players in Ghana must work together to create a regulatory framework that is clear, consistent, and adaptable to shifting market and technology conditions in order to overcome this difficulty. The goals of this framework ought to be to encourage competition, safeguard consumer rights, and guarantee the secure and dependable operation of smart metering systems.

4. MITIGATION STRATEGIES

This paper suggests some steps to help improve efficiency as well as reduce the cost of power generation and consumption at both the generator and consumer levels.

4.1 Making Use of Economical Technologies

The excessive implementation costs of Ghana's current smart metering system are a serious problem. The high expenses frequently act as a deterrent to mass adoption and reduce the system's efficiency. It is advised to investigate and implement affordable solutions like NB-IoT (Narrowband Internet of Things) to solve this issue. With NB-IoT, installing smart meters can be done more affordably, thereby easing the financial load on utility companies and customers. Ghana can overcome the cost barrier and improve the accessibility of smart metering systems by utilizing affordable technologies.

4.1.1 Mobile Network Roaming Service

Smart meters with roaming service have the potential to connect to various networks, improving coverage in places with poor or weak signal strength. This feature enables uninterrupted data transmission while assisting with connectivity issues. Smart meters with roaming capabilities can switch to an available roaming network in the event of network outages or disturbances, lessening the impact of such events. By minimizing downtime and allowing ongoing smart meter operation, this smooth network switching ensures consistent functionality even in the event of network disruptions.

4.1.2 Mobile Network Reliability

Meters should be updated to be able to connect with MTN and Airtel Tigo, among other network service providers. There are various benefits to this diversification of network alternatives. The first benefit is that it increases network dependability by enabling meters to switch to different networks in the event of general network outages or outages unique to a particular provider. As different network providers have varied coverage zones, it also increases accessibility and coverage. This makes it possible for meters to establish trustworthy connections for data transmission across a wide range of locations.

4.2 Proper Mounting of Meters

Meters should be mounted on the building of the consumer, the distance between the meter and the consumer is reduced when

the meter is mounted on a building since it is located nearer to the consumer. The likelihood of technical losses that might occur along the cable is reduced by shortening the line. In turn, this improves the precision of measuring electricity consumption. The same is true when meters are positioned in residential areas since it puts them near the customers they serve. The length of the electrical wires is cut in half by carefully placing meters in these locations. In addition to ensuring more precise assessments of electricity use, this helps to minimize potential technical losses.

4.3 Consumer Awareness Campaigns

The lack of customer understanding makes adopting smart meters in Ghana problematic as well. Smart metering systems may encounter resistance or mistrust from consumers who are unsure of their advantages and capabilities. It is essential to start extensive consumer awareness initiatives to address this problem. These advertisements ought to concentrate on informing the general public about smart meter benefits including precise billing, real-time energy monitoring, and improved energy efficiency. Consumers may make educated decisions and take an active role in the deployment of smart metering systems by increasing awareness and dispelling myths.

4.4 Data Protection and Security Measures

The safety and privacy of the customer data that smart metering devices gather must be ensured. It is crucial to safeguard customer data from unwanted access or breaches as energy infrastructure becomes more digitalized. Strong data protection and security measures must be put in place to reduce the dangers to data security. This entails implementing secure authentication mechanisms, using encryption to protect data during transmission and storage, and routinely updating security frameworks. Ghana can increase consumer confidence and guarantee the integrity of its smart metering systems by prioritizing data protection and implementing extensive security measures.

4.5 Regular Upkeep and Checking

Reliability is another issue with the adoption of smart meters in Ghana. The system must be maintained and monitored regularly to operate at its best. It is advised to create a thorough maintenance program that covers routine checks, smart meter calibration, and firmware updates. This proactive approach will assist in quickly identifying and resolving any potential problems or malfunctions. Utility companies should also put in place effective complaint-handling procedures to address customer concerns and fix any operational hiccups. Ghana may improve the dependability and performance of its smart metering system by placing a high priority on routine maintenance and monitoring.

5. CONCLUSION

This work highlighted the issues preventing Ghana from successfully implementing smart metering systems. It is crucial to create and put into place effective mitigation measures in order to address these issues and guarantee the adoption of smart meters. Ghana may overcome the barriers preventing the widespread use of smart metering systems and realize their full potential by adopting these steps.

Utilizing affordable technology, like NB-IoT, is a crucial mitigating strategy. By utilizing these technologies, Ghana can reduce the costs of installing smart metering systems, making them more accessible and cheaper for a wider range of people.

This benefits not only specific consumers but also the broader economic growth of the country.

Running targeted consumer awareness campaigns is another key strategy. Ghana may promote a deeper knowledge and adoption of this technology by informing people about the benefits of smart metering systems. The advantages of accurate invoicing, understanding energy consumption, and the capacity to make knowledgeable decisions regarding energy use should all be emphasized in these efforts. Ghana may encourage greater participation and engagement with smart metering systems by arming people with information.

To address the problems with data protection and security, strong steps must be implemented. By adopting other security measures to maintain privacy and prevent unauthorized access, smart metering systems can safeguard client data by encrypting it. Ghana may boost consumer confidence and develop conviction in the dependability and integrity of the smart metering system by giving data protection a priority.

Priority must also be given to routine maintenance and upkeep. Ghana can increase the dependability and accuracy of smart metering systems by putting in place a strong maintenance plan and calibration procedures. The longevity and ideal performance of the infrastructure are boosted by prompt replacements and repairs, as well as by routine firmware updates.

By putting these mitigating strategies into place, Ghana can support its long-term sustainability objectives while also improving energy management and efficiency. Better resource management, less energy waste, and improved grid management are all made possible by smart metering systems. These advantages help Ghana move toward an energy future that is more ecologically friendly and sustainable.

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