DEPLOYMENT OF SMART METERS TO ELIMINATE ENERGY THEFT IN NIGERIA

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Abstract: *The supply of electric power is seen as a very important and key driver in the efforts to diversify and grow the economy of Nigeria to boost revenue sources and create employment opportunities for the teaming youth. However, there are several problems and challenges that are adversely affecting the electricity sector in the Nigeria. A critical aspect of these challenges is energy theft, which include unethical practices such as unlawful direct hooking from power line, by-passing of electricity meter, injection of foreign elements into the energy meter, drilling holes in the meter and assignment of illegal amount of energy units to consumer. In this paper, a phased deployment of smart energy meters and other managerial procedures are recommended to drastically reduced incidences of energy theft with subsequent increased in revenue collection. This paper would be useful to policy makers who are trying to come up with effective solutions aimed at boosting revenue leading to improvement in power generation sector, transmission process and distribution.*

Keywords: *Electricity Sector, Energy, Theft, Electricity, Meters, Energy.*

Introduction / Background Study

In recent times, there are intensified efforts to further develop and diversified the economy of Nigeria, which in the past has based mainly on the exploration and export of crude oil, which has been referred to by some people as the black gold due to its immense and great economic value (Omofonmwan & Odia, 2009; Parsons, 2010). According to the recent data from the Nigerian Bureau of Statistics, crude oil exploration and sales contribute about 82% of Nigerians gross exports (Nigerian Bureau of Statistics, 2018). In the last two decade, the nation's earnings from oil sales is in the excess of ₦90 trillion (Dickson & Ezirim, 2017; Odularu, 2007). In spite of these positives, oil revenue which is the main source of revenues is subject to constant variations, and easily influenced by international policies usually out of the control of the nation producing it. More so, there is gross infrastructure deficit in the country that will require a diversified revenue sources to overcome. In the meantime, several nations are shifting attention away from fossil fuel based energy sector to renewable energy. This trend would impact negatively on oil demand and consequently lowering prices. Therefore, it has become critical that the Nigerian economy be immediately diversified. Electric power supply is seen as a one of the key driver in the efforts to diversify and grow the economy of Nigeria, thereby boosting revenue sources and creating employment opportunities for the teaming Nigerian youth (Emodi & Yusuf, 2015). However, there are numerous challenges mitigating and affecting the generation, transmission and distribution of electricity in the country called Nigeria. Some of these challenges have been examined by researchers such as Iseolorunkanmi (2014), Obadote (2009) and Sule (2010). Highlight of most of them are obsolete and dilapidated equipment associated with aging and lack of inadequate maintenance policy, poor managerial efficiency, limited funding and low connection rate (according to Abubakar (2009) access to national grid electricity is 40%). Others include grossly insufficient capacities in generation, transmission, and distribution with very poor system average interruption duration index. Others are, ineffective regulatory framework, linked with inefficient energy tariff structure and poor enforcement of existing law (Ndinechi et al. 2011), unacceptably high technical losses, inadequate gas supply, which is an issue because a bulk of generated electric power is from gas. Also included are constraints in gas supply are compounded by the militancy in the Niger Delta region of the county, insecurity leading to the kidnapping of foreign technical partners and expatriates, and vandalism of power infrastructure as well as general negative attitude on the part of the customers (Ndinechi et al., 2011). Energy distribution per capita for some selected countries is shown in the table below.

Table 1: Energy consumption per capita of some selected countries in KWh

Countries	2004	2009	2014
Botswana	1428.39182	1716.76989	1748.61533
Brazil	1948.4086	2185.74526	2601.36551
Canada	17235.4118	15450.8796	15541.5045
China	1585.83878	2612.45662	3927.0445
Algeria	800.704308	863.085974	1356.26455
United Kingdom	6138.75414	5643.12859	5129.52779
India	453.010206	600.201702	805.599191
Nigeria	123.565649	120.574722	144.479924
United State	13388.5897	12913.7147	12986.7407
Tunisia	1035.07816	1274.58768	1444.1074

Data was sourced from World Bank (2016)

Other challenges include consumer related fraudulent practices, such as unlawful direct hooking from power line, by-passing of electricity meter, injection of foreign elements into the energy meter, drilling holes in the meter and assignment of illegal amount of energy units to consumer. Smith (2004) analyzed electricity theft by comparing 102 countries. In the opinion of Smith (2004) knowledge is key to addressing energy theft, and as such power companies should periodically present detailed power theft analysis-outlining why the theft occur and perpetuating factors. To address some of the aforementioned challenges, smart meters have to be acquired and universally deployed throughout the country. In the remaining part of this article the smart electricity meter and research works on smart meters will be described, forms of energy theft, challenges to electricity metering in Nigeria, and proposed solutions.

Electricity Meter Description

Types of Meters

There are various types of electricity meters used in Nigeria and Figures 1, 2 and 3 shows electromechanical, prepaid and smart meters respectively. The electromechanical meters have a spinning disc and a mechanical counter display unit. It operates by counting the number of revolutions of a metal disc that rotates at a speed proportional to the power drawn through the main fuse box. Close proximity coils spin the disc through induction of eddy currents with a force proportional to the instantaneous current and voltage. A permanent magnet exerts a damping force on the disc, stops spin after power has been removed to prevent customer from over-billing. This class and type of meters has a number of limitations that has made it grossly irrelevant and immaterial for use in smart energy drive environment which include but not limited to its degree of accuracy (Ndinechi et al., 2011). A prepaid electricity meter is a Kilowatt Hour (KWH) meter counts backwards as the electricity is consumed and has a relay, which disconnects the power when the KWh reading on the meter reaches zero. The meter includes a hardware unit capable of deciphering the pin number entered and convert it to KWh. Prepaid Meters works with software, programmed to only generate a token if the meter is in credit. The token (pin number) can be deciphered by the meter and converted to KWh (Prepaid Electric, 2018). Prepaid software functions by using Standard Transfer Specification (STS) technology. An STS compliant prepaid meter can function on any STS compliant software. Since there are several manufacturers of prepaid and software providers, a specific prepaid meter has to be registered on a specific software package before it will function. All STS compliant prepaid meters are identified by an 11-digit code, and can only be linked to one software package at a time. In order for a prepaid meter to switch to a different software package, the current software supplier as well as the new software supplier need to issue a code, which is physically punched into the meter, before the meter will accept tokens generated by the new software company (Prepaid Electric, 2018). In the next sub-section, our attention will be focused on smart metering paradigm.

Figure 1: Electromechanical meters

Figure 2: A typical pre-paid meter

Figure 3: A smart meter

Smart Meters

A vast majority of energy meters in Nigeria are post-paid electromechanical meters, which are described in Ehiagwina (2016). They are characterized with low accuracy, a lack of re-configurability and not capable of detecting or preventing energy theft. In more recent times, pre-paid electricity meters are being deployed in the country with several advantages including improved security and privacy since there is no human meter readers coming in to the premises of customer, there is no billing inaccuracies and ease of monitoring the rate of energy consumption, etc, as part of the results. Anyway, prepaid meters on their own are not capable of detecting as well as reporting energy theft (Dike et al.2015; Instant energy, 2018). Therefore, the new and latest smart electricity meters have been developed to address even the most advanced form of energy theft coupled with their contributing to proper and efficient use of energy (Anas et al., 2012). In addition, the smart meters will aid real-time tariff system and network monitoring (Oshevire et al., 2013). Smart metering scheme comprise of different components that may vary depending on the specifications of the locality where implementation will take place. By concept, a smart meter should be capable of two-way communication with several appliances and devices, providing accurate readings automatically at specified time interval (ESWIG, 2018). Communication techniques used include Power Line Carrier (PLC), Bluetooth standard, global system for mobile communication (GSM), Internet protocols. Session Initiation Protocol (SIP) are sometimes used for controlling of Voice over Internet Protocol (VoIP), Zigbee 802.15.4 may be used in Home Area Networks (HANs). However, there are concerns with privacy of customers and radio wave interference with existing telecommunication systems (Anas et al., 2012). In the implementation of the smart meters

communication network, the global system for mobile communication (GSM) technology is a candidate solution because it is ubiquitous, standardized and easily implementable. Dike et al. (2015) proposed the incorporation of GSM into the prepaid energy meter for increased generation of revenue in developing countries like Nigeria. The proposed meter is expected to bear a unique identification number such as the consumer's phone number which may be encrypted into the memory of the microcontroller. From the results obtained from the simulation shows and indicate that soon after an illegal load is connected to the utility system either within the residential meter jurisdiction or otherwise, the GSM module will alert the utility company irrespective of the size and magnitude of the load. Abdulwahab (2009) advocated for the introduction of advance computerized system to manage billing because of the following in connections with the data and operations involved: sheer volume of data, complex calculations, repetitive operations, quicker response time, and detection and reduction in fraud. In this wise, Anas et al. (2012) noted that smart meters could be used for self-billing, in addition to capability to connect and disconnect users, and remote authentication.

Meter Specifications

The specifications of meters acceptable for use in Nigeria are shown in Table 1. This specification allows for safety, standard and uniformity.

Table 2: Typical specifications for distribution meters

Parameters	Specified Value
Voltage rating	240/415V
Operating voltage	-40% to 10%
Current rating	5(60) A
Frequency	50Hz±2%
System	Single or three phase
Operating temperature	-10 0C to 55 0C
Internal battery or an equivalent giving a total stand-by life of 10 year (min.)	Lithium CR 2025-1HF
Auxiliary battery for downloading	12 DC supply
Accuracy class	0.5s for 33kV, 0.2s for 132 & 330kV
Storage temperature	Up 70 0C
Life span	10 years
Relative humidity (non-condensing)	Up to 96% @45 0C
Burden	2VA/phase in voltage circuit and 1VA/phase in current circuit

Data sourced from (Ewesor, 2010)

Challenges in Electricity Metering in Nigeria

Estimated Billing

Available statistics indicate that about 60% of connected households are unmetered. Worse still, a good number of available meters are faulty (Nigeria Electricity Hub, 2017). These factors have contributed to the unpleasant culture of estimated billing, with the tendency that some customers are over-billed. More so, some customers are unwilling to pay estimated bills, leading to loss of revenue.

Energy Theft

A major problem working against the growth of the electricity sector in Nigeria is the issue of energy theft, coupled with unwillingness of customers to pay. There are various forms of energy theft discussed in the literature for example Smith (2004), and they are subsequently highlighted.

Meter Tampering

This could either be tampering the meter physically or grounding of the neutral wire, and thereby causing the meter to suppose an incomplete circuit. Consequently it will fail to measure power drawn by a connected load. Similarly, meter by-pass occurs when both input and output terminals are shorted, and consequently, power flow from being registered. Tapping of overhead lines on the Low tension side of the transformer, resulting in overloading, which in turn may cause system tripping and blackout (Dike et al., 2015). Other energy theft methods include: Tapping to bare wires and underground cables, which account for majority of energy theft. Unpaid bill by individual, government agencies and so called 'untouchables' in the community. Also of importance is billing irregularities such as under-billing and fixing of bills by compromised employees. Anas et al. (2012) mentioned some method of stealing energy even under the smart metering dispensation. They include software hacking in which during authentication, data tempering occurs. False authentication can be used to authenticate the password and hack the data from smart meter. Some hardware hacking, methods mentioned for electricity theft in electromechanical meter can be applied to smart meters as well, except putting magnet of neodymium, inserting disc, or hitting it, and by this mechanical, shock the meter would not work properly. In spite of these, the smart electricity metering paradigm represents the most advanced metering system to minimize energy theft.

Meter Manufacturing Challenges

In Nigeria a bulk of metering service providers are either importers, corporate installers, or vendors. However, some meter manufacturers in Nigeria also exist. Examples are Mojec Internal, Momas Systems Nigeria Limited, Metering Solution Manufacturing Service Limited, etc. They are not able to close the yawning gap between meter demands and supply due to some mitigating factors, such as high capital required, foreign exchange associated challenges like high exchange rate and scarcity of forex needed to import some components needed to manufacture meters. Another challenge being faced by meter manufacturer in Nigeria is the stiff competition with their foreign counterpart. Some customers (Distribution Companies) seem to prefer imported meters to locally manufactured equivalent. The provision of incentive to meter manufacturers in terms of policies and tax holidays are recommended. Regulatory agencies could instruct Distribution Companies to patronize these manufacturers so that they can continue in business.

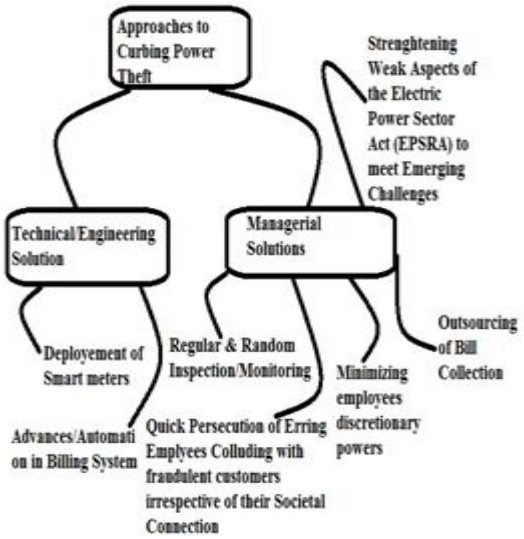

Figure 4: Approaches to curbing power theft in Nigeria

Solutions towards Curbing Energy Theft

There are various approaches to curbing energy theft and they are classified into technology/engineering approach and managerial efficiency approach (Smith, 2004). The solutions proposed by Smith (2004) are modified in the taxonomy shown in Figure 4 to meet the peculiarities of Nigerian electricity sectors in her drive for economic diversification and development. In the case of technological based solution to the problem, the deployment of smart meters is suggested and hereby recommended. However, privacy issues have been raised by some in connection with the use of smart meters (Garcia & Jacobs, 2011; McKenna, e tal. 2012; Rial & Danezis, 2011). For some examples, if fine grain data of consumer energy consumption are transmitted, the security of the customer might be compromised. The utility company and any other potential intruder may tell easily when the customer is around or away from home, and what the customer is doing at home. Owing to the issues of privacy in connection with the assessment and use of consumer data raised by some, the development of a framework is recommended, in which aggregated readings are transmitted to the power company randomly and by so doing, the predictability of sensitive data of customers are minimized. Non-essential consumer data such as per minute energy consumption readings are not required most of the time, hence should not be made available. Smart meters should only send information needed for operations and billing (Anderson & Fuloria, 2010). Prior to sharing consumers information with third parties like government agencies customer consent should be obtained. Doing this will foster a sense of security and privacy on the part of consumer. Electricity regulators must be operationally and financially independent to drive ethics with regard to data management of sensitive consumer information. In addition, smart meters should be based on open industrial standard to facilitate communication between generating companies, distributing companies and regulators (Anderson & Fuloria, 2010). Due to the huge cost required to universally deploy smart meters, a phased deployment of smart meters in the country is recommend. In "Phase A", the unmetered consumers are smartly metered. In "Phase B", consumers with electromechanical meters should have their meters replaced with smart ones. Finally, existing prepaid meters installed in customers' premises are replaced with meters enabled with communication facilities. The deployment of smart meters will eliminate energy theft, and address some of the core issues bedeviling the electricity sector in Nigeria.

Conclusion

In this review article, the key challenges besetting the Nigerian electricity sector had been highlighted. It is argued that a grossly inadequate metering compounds the situation. Finally, a phased deployment of smart energy meters and other managerial procedures had been highlighted to drastically reduced incidences of energy theft. This article can help policy formulators in the energy sector to come up with effective solutions aimed at improving power generation, transmission and distribution. Currently, the few electric meter manufacturers in Nigeria require support from regulatory agencies and government in the way of policy

formulation and tax incentives. However, on the long term, smart metering is the way to go. Local design, development and fabrication of smart electricity meters that take into account some of the challenges and recommended solution should be pursued. Also, the managerial solutions highlighted should be studied in the Nigerian context to promote efficiency and reduction in energy theft.

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